

UTILIZATION OF SUGARCANE BY-PRODUCTS:  
APPROPRIATE AND INAPPROPRIATE TECHNOLOGIES IN MAURITIUS

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Ph.D

University of Edinburgh

1982



### ABSTRACT

Agricultural wastes are a possible resource for the establishment of rural industries in many, especially tropical, parts of the world.

This thesis considers the critical problems of monoculture plantation economies, particularly on isolated islands, and analyses possible strategies to use wastes beneficially. The concepts are amplified, for sugarcane by-products, by a series of case studies of attempts to produce higher value products from them. Detailed investigations into the establishment, and subsequent performance, of a bagasse particleboard factory and an active dried bakers yeast factory, both in Mauritius, are given.

A comparative study is made of some existing 'Third World' cane spirit distilleries and alternative small and medium scale processes for bagasse pulp and paper production.

From the detailed case studies broader conclusions are drawn on the introduction of new technologies as a historical process; the design process involved in investigating and implanting new technologies and how, in its absence, completely inappropriate technologies may be chosen; technology as not just the production machinery but also the set of social relationships which enable the product to be produced and used in a given society; the need to search for more alternative technologies before starting the design process; and the effects of conflicts of interest upon technological decision-making.

### DECLARATION

I declare that this thesis has been composed by myself and that the work contained within it is my own.

D. R. Newman



### ACKNOWLEDGEMENTS

I would especially like to thank my supervisor, Mr. H. Dickinson, for his constant stream of stimulating and provocative ideas which aroused and maintained my interest in the subject. I am equally indebted to the man who stimulated the world to take seriously the use of sugarcane by-products, and who pointed me in the right directions when I arrived in Mauritius, M. Maurice Paturau.

I am extremely grateful for the superhuman patience of those who took time from their work to explain in great detail their projects, in particular M. Serge Duvergé (Yeast Producers (Mtius) Ltd.) and M. Maxime Raffray (Universal Board Co. Ltd.).

Thanks are due to Prof. Lim Fat and colleagues at the School of Industrial Technology, University of Mauritius for their support when I was in Mauritius, and to the librarians of the University of Mauritius, of the Mauritius Sugar Industry Research Institute, of Tate and Lyle Group Research and Development Ltd., of the Tropical Products Institute and the Instituto Nacional de Açucar (Maputo) for permitting me to study in their libraries.

I would also like to thank the following:

José Allet, Bansul, Guy Beaubois, Bhaskar, Burrenchobay, Chandrakant, Chevreau, D'Espaignet, Claude De Laitre, Nunkoomar Deerpalsing, Desai, Pierre Dinan, Leo Edgeley, Hookoomsingh, Hugnin, Basdeo Joynathsing, Daniel Lagesse, Luc Lam, Léclezio, Georges Leung Shing, Carl Mapoun, Phillipe Martin, Maujean, S. R. Mehta, Peter Ming, Kishore Mundil, Naidoo, Narain, Roland Nicolin, René Noël, Owadally, Eric Piat, Priscoll, Raymond Raffray, Rajabally, K. Ramdeehul, Jean Rey, Rouillard, Gerald de Senneville, H. Unmole and B. Wong in Mauritius.

Agrawal, C. S. Bhatt, Bisweet Brahmchary, Radheysham S. Gupta, Rajesh Khandelwal, N. H. Kulkani, S. K. Muckerjee, N. A. Ramaiah, B. Ramaroo, V. C. Sharma, Man Mohan Singhal, H. R. Srinavasan and W. A. Wellankar in India.

A. M. El Sherbini and Mahmoud Fouad in Egypt.

Robin Alpine, Andrew Barnett, Donald Chesworth, Fiona Duguid, David Edge, Nick Emery, Alistair Fraser, David O. Hall, Hawkes, Jean Hubert, W. J. A. Payne, Leo Pyle, Joe Reinhardt, D. Walker, P. Watson and Williams in the UK.

I also wish to thank all those who helped in this thesis who were not included through chance forgetfulness, loss of address books or other such accidents.

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## UNITS AND ABBREVIATIONS

The Syst me International d'Unit s is used throughout except in quotations, where the authors' units are given, with metric equivalents when American authors insist on using obsolete units. The conversion factors used are those given in the National Physical Laboratory booklet(1), and the style used is that given in the Metri-cation Board booklet, 'How to write metric'(2).

For consistency, per annum is rendered as /a throughout, per day as /d, per hour as /hr. SI prefixes of k (kilo), M (mega) and G (giga) are applied to currency as well as physical units. Thus US\$1 M is one million United States dollars. When possible, currencies are converted to US\$, except for Mauritian rupees (Rs). Average exchange rates as published by the IMF were as follows:

1970	5.56 Rs/US\$
1971	5.46 Rs/US\$
1972	5.34 Rs/US\$
1973	5.44 Rs/US\$
1974	5.70 Rs/US\$
1975	6.03 Rs/US\$
1976	6.68 Rs/US\$
1979	6.40 Rs/US\$

There have since been devaluations of the rupee in 1979 and 1981.

### 1. Abbreviations

/a	per annum
ACP	African, Caribbean and Pacific countries associated with the EEC
ADY	air dry yeast
ATDA	Appropriate Technology Development Association, Lucknow, India
BABA	British Anaerobic and Biomass Association
BIOS	British Intelligence Objectives Sub-committee
BOD	biological oxygen demand
BRD	Bundesrepublik Deutschland
CARICOM	Caribbean Community
CEB	Central Electricity Board, Mauritius
CEDIMO	Centro de Documenta��o e Informa��o de Mo�ambique
c.i.f.	cost, insurance and freight
Co.	Company
Cofuna	Compagnie des Fumures Naturelles (and their compost accelerator)
cs	centimes
ct	cent



/d	per day
DBM	Development Bank of Mauritius
DCL	Distillers Company Ltd.
Dir.	Directorate
DM	Deutsche Mark
DSR	an East German shipping line
ECN	European Chemical News
EEC	European Economic Community
EtOH	ethanol
ETSU	Energy Technology Support Unit, UK
FACIM	Feira Commercial e Industrial de Maputo
FAO	Food and Agriculture Organisation of the United Nations
f.o.b.	free on board ship
FRG	Federal Republic of Germany
l	10 <sup>3</sup> litres
Govt.	Government
HFCS	high-fructose corn syrup
HMSO	Her Majesty's Stationery Office
IAA	Instituto de Açucar e Alcool
IBP	International Biological Programme
ICIDCA	Instituto Cubano de Industrialisacion dos Derivados de Cana de Azucar
IDB	International Development Bank
IDRC	International Development Research Centre, Ottawa
IEA	International Energy Agency
IFLOMA	Industrias Florestais de Manica
ILO	International Labour Organisation
IMF	International Monetary Fund
Int.	international
IPT	Instituto de Pesquisas Tecnológicas do Estado de São Paulo
IRR	internal rate of return
IRs	Indian rupees
ISBN	International Standard Book Number
ISES	International Solar Energy Society
ISSCT	International Society of Sugar Cane Technologists
ITDG	Intermediate Technology Development Group, London
ITIS	Intermediate Technology Industrial Services
J\$	Jamaican dollar
KCFP	Kenya Chemical and Food Project
kgal	10 <sup>3</sup> gallons
kl	10 <sup>3</sup> litres
kRs	10 <sup>3</sup> Rupees
kt	10 <sup>3</sup> tonnes
kUS\$	10 <sup>3</sup> US dollars
KVIC	Khadi and Village Industries Commission, India
LSU	Louisiana State University
MCA	Mauritius Chamber of Agriculture (also Mauritius College of the Air, but not used here)
MCCI	Mauritius Chamber of Commerce and Industry
MDF	medium-density fibreboard
Mgal	10 <sup>6</sup> gallons
Min.	Ministry
Misc.	Miscellaneous
ml	10 <sup>6</sup> litres
MMM	Mouvement Militant Mauricien

MMSP	Mouvement Militant Mauricien Socialiste Progressiste
MRs	10 <sup>6</sup> rupees
MSG	monosodium glutamate
MSIRI	Mauritius Sugar Industry Research Institute
MSPA	Mauritius Sugar Producers Association
Mt	10 <sup>6</sup> tonnes
Mtius.	Mauritius
Neth.	Netherlands
NIMEXE	a trade classification used in EEC statistics
NPV	net present value
nr.	near
NRDC	National Research and Development Corporation
OAS	Organization of American States
OECD	Organisation for Economic Cooperation and Development
OSB	oriented structural board
PROSI	Public Relations Office of the Sugar Industry, Mauritius
Rp	Indonesian Rupiah
Rs	Rupees (Mauritian unless otherwise noted)
RSA	Republic of South Africa
SCP	single cell protein
SERI	Solar Energy Research Institute, Golden, Co., USA
SI	Système Internationale
SIDO	Small Industries Development Organisation, Tanzania
SILWF	Sugar Industry Labour Welfare Fund, Mauritius
SIPAQ	a pressed yeast factory in Maputo
SITC	Standard International Trade Classification
SOFECIA	Société Financière d'Entrepôtage et de Commerce Internationale de l'Alcool
SP	São Paulo
TPI	Tropical Products Institute, UK
TSC	Taiwan Sugar Corporation
UBC	Universal Board Co. Ltd., Mauritius
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNFPA	United Nations Fund for Population Activities
UNIDO	United Nations Industrial Development Organisation
UNITAR	United Nations Institute for Training and Research
USA	United States of America
USDA	United States Department of Agriculture
USSR	Union of Soviet Socialist Republics

## References

1. Anderton, Pamela and P. H. Bigg, Changing to the metric system - conversion factors, symbols and definitions, HMSO for National Physical Laboratory, London (1979).
2. Metrication Board,, How to write metric - a style guide for teaching and using SI units, Her Majesty's Stationery Office, London (1977).

## CHAPTER ONE

### Introduction

This thesis is an attempt to analyse a potential solution to some of the more pressing problems of underdevelopment. Such problems include:

- i. The effect of increasing prices of imported raw materials, especially oil, upon the balance of trade, and upon local industries.
- ii. Establishing new industries in areas without abundant, evenly distributed, mineral resources.
- iii. Rural unemployment and underemployment leading to migration to the cities.
- iv. Generating a sufficient agricultural surplus to improve the living standards of the rural people and provide for investment throughout the economy.
- v. Shortages of construction materials.
- vi. Shortages of animal feed and food in areas where the land is used for plantations of cash crops.
- vii. The import dependence of industries in peripheral areas, especially islands.

The particular solution proposed can be stated in its most general terms as "the use of agricultural and forestry wastes". These are the one resource common to all underdeveloped countries (with the

exception of countries which are completely desert). Whereas mineral resources are unevenly distributed around the globe. For example, out of 39 Sub-Saharan African countries\* only four were oil exporters, and only 9 had enough exploited mineral wealth to be able to provide more than 15% in value of their total exports(1,p.150).

Agricultural and forestry wastes can be, and have been, transformed to products to provide fuels, construction materials, animal and human food, chemicals, fertilizers and fibrous products. The great variety of potential products has long been appreciated by farsighted foresters, farmers, chemists and engineers. In 1947 Egon Glesinger wrote a book called "The Coming Age of Wood"(2), in which he explained how wood was extensively used during World War II as a source of producer gas, charcoal and activated carbon, methanol, acetic acid, tars, sugars for fermentation to yeast and alcohol, fat and protein, and how it can be converted to many more products, in this way acting as the universal raw material for developing countries. Hence the title. The age of wood did not come. Wood hydrolysis plants in the United States were bought by oil companies and closed down, so ensuring the dominance of petrochemicals.

As the cheaper resources, built up over centuries of photosynthesis are depleted (world oil production rates have been predicted to start declining in the 1980s(3,p.177)), the present-day photosynthetic energy income will have to be used as a resource. Development strategies will have to consider the optimum use of biomass. Already studies have been written on the use of biomass for developing coun-

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\* Excluding Cabo Verde, the Comoros, Djibouti, Equatorial Guinea, São Tomé and Príncipe, and the Seychelles. As usual many of the countries ignored were islands.

tries(4), although these have concentrated on energy production from biomass to the exclusion of other, higher added value, uses.

What advantages are there in the utilization of biomass? In rural areas the only production usually found is agricultural production. The fortunes of the local people depend on the surplus which they can produce over their immediate needs. However, it is this surplus which is taxed in most underdeveloped countries to provide capital for investment in industry and services and infrastructure for those who live in the cities. In few areas is the agricultural surplus sufficiently high to provide substantial tax revenue and a rapid improvement in rural incomes. Furthermore, as the cost of borrowed money increases#, there is more pressure on governments to raise capital internally; which means, in countries with no oil or mineral wealth, and a very small manufacturing sector, increased taxation of agricultural production. If, however, the value of agricultural production can be increased by transforming the wastes or by-products into products with added value, the total surplus in an area will be increased, allowing an increase in rural incomes.

In a number of underdeveloped countries, there is pressure on land tenure, as a result of subdivision of plots upon inheritance when the population is increasing, or of expropriation of land by large landlords or governments or plantation projects, or of forfeiture of land to moneylenders. Under such circumstances, the numbers of landless labourers and families with insufficient land to provide for their own needs increases. In the absence of rural industries these people drift to the towns to be unemployed there, and to

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# Measured by the high interest rates charged at present in commercial markets.

increase the burden on municipal services.

What kinds of industries could be set up in rural areas? There are many advantages to the industrialist of locations in cities. The markets are either in the cities, or exported from port cities, as rural incomes are too low to generate demand for anything except basic consumer products.<sup>†</sup> Even for these consumer products, high transport costs and low rural population densities favour production in cities. Small scale industries, producing consumer products in rural areas, do not suffer high transport costs for their products, but have to pay substantially higher prices for raw materials other than those produced locally. Furthermore, shortages caused by irregular deliveries of raw material and spare parts more frequently affect industries away from major cities.<sup>‡</sup>

Other factors which inhibit the introduction of rural industries are a lack of rural convertible capital<sup>‡</sup> available for investment in rural industries, while those with the money to start industries live in towns and, therefore, tend to invest there; and that siting of industry in rural areas requires more training of the workers and/or redesign of the plant.

For these, and other, reasons, most industrialization continues to be concentrated in the cities, and does not benefit the rural population. However, there is a notable exception to this general

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<sup>†</sup> From salt to bicycles.

<sup>‡</sup> The cashew processing factory in Angoche, Moçambique produces at a lower percentage of its capacity than those in Maputo, for this very reason.

<sup>‡</sup> What accumulated wealth there is tends to be used for marriages and other ceremonies. For many people the only means of raising convertible capital is by working as migratory labour in mines or plantations.

observation. These are industries based on the transformation of agricultural by-products. As these are often dispersed and bulky, the factories need to be sited near the raw materials, and it is usually cheaper to transport the product than the raw material. Hence Egypt's bagasse board and paper mills are in Upper Egypt alongside the sugar factories, from where the paper and board are transported to Cairo.

Such industries provide income for the local people both through factory wages and the purchase of by-products. Although prices paid for the by-products are often fixed at lower levels than would be paid if the factory was close enough to the capital for the growers to exert political pressure on the factory management<sup>§</sup>, there is still some money available to improve the local living standards.

So industries based on agricultural by-products could be one of the rare cases where industrial development is possible at the periphery rather than at the centre. An extreme case of such peripheral areas is an island. In terms of the world trade routes islands are the ultimate periphery. Because of their low volumes of trade, they tend to be served by minor shipping lines, and goods are often transhipped before reaching them. For example, to send yeast from Mauritius to Jordan, it was necessary to tranship in Marseilles (see Chapter 4). As a consequence of the low freight volume, and the absence of local shipping lines to compete with the shippers' conferences, freight rates are higher than the equivalent distances between larger countries. The following quotation from the 1980-2 Mauritius Plan(5,p.161) shows how dependent an island can be when freight rates are set.

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<sup>§</sup> For example, sugar cane prices in Brasil and India are well below the 74% of the sugar revenue paid to Mauritian planters.



There is no organisation in Mauritius responsible for freight negotiations and consequently freight rates are fixed by the Conference lines without any consultation whatsoever with the local authorities. It should be pointed out that any increase in freight rates is to the advantage of local shipping agents since their fees are calculated on a percentage basis.

In fact, the rates are so high that it was cheaper to supply yeast to Mombassa from Montreal than from Mauritius. A particular disadvantage of islands whose nearest neighbours are underdeveloped countries is that shipping is well developed between larger countries, and especially to and from Europe and North America; whereas shipping between countries at the periphery has to depend on tramp steamers or a few minor, non-conference, shipping lines.#

In short, such islands are effectively sea-locked, and suffer no less from this isolation than do land-locked countries. Industry suffers from difficulties in, and paying more for, the import of raw materials and the export of finished goods. Only when the goods are high-value and compact do these islands become favourable places for the transformation of foreign raw materials to produce for export, and even this is true only for as long as the islands can supply relatively cheap skilled labour. As oil prices rise the cost of freight will become ever more significant, making export processing zones (EPZ) on remote islands less and less favoured by foreign investors.

In view of these costs, it is not surprising that many islands concentrate their exports in a few commodities, shipped to a few countries. Knox(6) discussed the geographic concentration of exports from small developing countries, and showed that the concentration

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# e.g. Shipping Corporation of India, Besta Lines, DSR.



index\* for exports from small developing countries was 58.7 compared with 29.1 for large developed countries. He showed that the equivalent indices for commodity concentration were 46.2 and 21.4 respectively. Such concentration of exports allows the consolidation of cargoes, and lower charges.

A common form of this commodity concentration is the export of cash crops, especially plantation crops such as sugarcane, tea, and bananas. For historical reasons a number of islands in the Caribbean, the Indian Ocean and the Pacific are monoculture cash crop economies. These are under more severe economic pressure than those which depend on subsistence cropping or tourism, as the increases in oil prices and imported food affect them more.† Also, they run greater risks from changes in the price or the harvest of a single crop. Under such conditions industrial development takes on a certain urgency. For the prices of their cash crops are often limited by competition from temperate zone crops, and by increases in production in tropical countries exceeding demand as new countries start to plant the crop. Yet the costs of production (oil, fertilizers, labour, taxation, management perks, transport) continue to rise, together with the islanders' expectations. So imports of consumer goods and food increase while the income from the cash crop remains the same, thus squeezing the economy and especially, as always, those at the margins of it, leading to unemployment and a reduction in government services aimed at

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\* The concentration index is the square root of the sum of squares of the percentage shares of exports for each country of destination, or for each commodity. Complete concentration produces an index of 100, complete dispersion (between 100 countries or commodities) an index of 10.

† Oil prices because of the increased use of fertilizers and somewhat increased mechanization, food because the land is taken up by cash crops, and sea-locked countries have no possibility of occupying outlying land areas; it is sea, not land.

the poor (if the usual IMF model is chosen to regulate the economy).

Since monoculture of cash crops implies the production of large quantities of by-products, the idea of upgrading these by-products to useful materials whose prices might not rise and fall in step with the principle product has long been current in these island economies. Indeed, not only have agricultural by-product based industries been studied in these countries, but many of them have actually tried setting up such industries. Examples may be given from many countries including Taiwan, Cuba, Mauritius, Réunion, Jamaica, Sri Lanka, and Madagascar. These attempts serve as examples (good and bad) to the rural areas of larger countries where up to now such by-product use technologies have been scarce.‡

Accordingly, it was decided that there is an urgent need to make detailed analyses of cases of the introduction of by-product use technologies into one of the several hundred square kilometre laboratories, provided by island economies. This thesis is devoted to the study of the technical, economic and social relationships of such technical interventions. That a particular technology may work in a developed country or on a laboratory bench, but not prove adaptable to an underdeveloped country has long been recognised. An island has several advantages for making such a study; it can be studied in comparative isolation, as it is at the periphery of many centres§, and so does not need to be analysed as the periphery of one centre. All statistics are collected for the island, not agglomerated with other

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‡ Probably as a result of lack of capital in the hands of the rural people, and a lack of any sense of urgency on the part of decision-makers in distant capitals.

§ Except for those islands which are still colonies or theoretically part of a European country, despite being in the Caribbean or Indian or Pacific Oceans.

areas, and are often more accurate than in countries where the population overwhelms the statisticians (e.g. Nigeria). The number of people involved in any project or activity are limited, so it is within the bounds of possibility to see everyone concerned.

Simultaneously with the decision to study by-product utilization on an island, a decision had to be made on what crop and its wastes would be studied. There are, indeed, many tropical crops with a potential for more intensive use of their by-products, for example:

- i. The coconut palm. Although it is intensively used in countries such as India and Sri Lanka, in many other places only the copra is extracted, while the coir fibre and husks are thrown away. The husks are used in some places to produce charcoal and active carbon, producer gas or just as a fuel. The fibre has many uses, in matting, ropes and upholstery to name just a few.
- ii. Wood. Logging wastes (branches, stumps, thinnings and disused and unsuitable wood) can amount to a third or more of the quantity of lumber removed, and sawmill wastes can reach half of the timber processed(4). These sources of waste wood have been used for their fibre content in particleboard and fibreboard plants, and as a source of fuel (by direct combustion or pyrolysis to charcoal and wood gas). Of their other uses, among the many described in "The coming age of wood"(2), are hydrolysis to sugars, followed by fermentation to produce yeast or alcohol or citric acid.
- iii. Cereal straw. Straw has traditionally been used in some areas as a raw material for handmade paper and strawboard production(7), and for thatch, animal feed and as a fuel. A factory at

Sittingbourne is producing fruit boxes from resin bonded straw. As a lignocellulosic material, straw can, in principle, be converted to all the same products as wood. Rice straw is the principle fuel in many rural areas of China(8).

- iv. Cassava. Although not a by-product, it can be grown on unused land in quantities above those needed for food, as a source of starch which can be transformed into ethanol (as in Brasil), fungal protein for pig feed(9,10,11,12), and forms of industrial starch for various uses.
- v. Sugarcane. There is a long history of the utilization of the by-products of the production of sugar from cane. This involves the separation of a solution of sugars from the lignocellulosic fibres (the bagasse), the purification of this solution by precipitation with lime (to produce the filter mud), concentration of the sugar solution and crystallization of sucrose leaving behind a concentrated solution of invert sugars and inorganic chemicals (the molasses). In the field the cane is separated from the cane tops and the leaves (the trash). Such a variety of by-products can be transformed into correspondingly large number of products.

Since sugarcane can be transformed into products based on fibres, lignin, cellulose and sugars, it provides a model for the transformation of most other agricultural wastes (except purely starch-containing ones). As many of the by-products are produced at the factory, there is no cost of collection (unlike straw) and, therefore, there have been more commercial attempts to use the by-products of sugarcane. There is a long history of the use of sugar-

cane by-products, starting from the production of rum from molasses in the earliest days of sugar production.

For all these reasons, sugarcane was chosen as the crop for this study. Figure 1.1 lists many, if not all, the products which, according to the literature, can be produced from sugarcane by-products.

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**Figure 1.1 Checklist of uses of sugarcane by-products.**

<u>By-products:</u>	<u>which can be used for, or can be transformed into:</u>
Filter mud	Cement, calcium carbonate, calcium oxide, fertilizer, animal feed, and wax.
Molasses	Bacterial soil conditioners, food, phenol-molasses-aldehyde resins, in metallurgical flux, steel deoxidant, diffusion retarder in cement or lime hardened pottery, briquetting of directly reduced iron and ferrous metal fines, in refractory linings, in tiles and sanitary ware, cultivation medium for producing bagasse storage bio-liquor, in rice bran oil refining, in cements and foundry moulds, as pesticide carrier, glycerol, 1-ephedrine hydrochloride, ethanol, rum, gin, brandy, vodka, cane spirit, fodder yeast, carbon dioxide, butanol, acetone, isopropanol, 2,3-butanediol, citric acid, vinegar, <u>Chlorella</u> , <u>Verticillium</u> , <u>Rhizobium</u> , potassium oxide, bakers yeast, ammonia, acetic acid, glutamic acid and mono-sodium glutamate, lysine, tryptophan, arginine, valine, itaconic acid, lactic acid, oxalic acid, ribonucleic acid, succinic acid, acetoin, antibiotics, butadiene, ethylene, dextran, enzymes, fusel oils, gibberellins, propylene, lipids, tanning, corrosion inhibitor, butyric acid, gluconic acid, aspartic acid, iso-amyl alcohol, vitamin B <sub>12</sub> , kojic acid, dihydroxyacetone, graphite binder in aluminium manufacture, pelleting carbon black, insulating varnish, and carotenoids.
Molasses vinasse	Fertilizer, fodder yeast, irrigation, animal feed, biogas, mushrooms and potassium salts.
Bagasse	Fuel, animal feed, dissolving pulp, protein, pulp paper, particleboard, fibreboard, furfural, corrugated roofing boards, thermoplastic panels,

electricity, fertilizer, mushrooms, oil absorption, sugars, tobacco substitute, cork substitute, wound treatment, lignocellulose-poly(methyl methacrylate) copolymer composites, insulating materials, yeast recovery, ethanol, pyrolysis oil, biogas, ammonia, active carbon, cellulose acetate, carboxymethyl-cellulose, cellulose, cellulases, lignin, methanol, xylitol, anti-tumour polysaccharides, synthetic natural gas, briquettes, charcoal, producer gas, poultry litter, bagasse concrete and cement, furfuryl alcohol, explosives, formic acid, levulinic acid, dextrose, acetylene, compost, and bagasse reinforced resin.

Fly ash	Fertilizer, filter medium for cane juice, and glass.
Cane tops/trash	Animal feed, leaf protein, compost, mushrooms and mulch.

Note: These are suggested, patented or tried uses mentioned in the literature. Few have reached commercial viability. For a diagram showing the principle uses of sugarcane by-products, see the figure in the literature survey that has been reproduced from Paturau(13). Sources: Literature surveys by Kort(14).

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Such a variety of products can be produced by making use of different properties of the by-products. Molasses is a reasonably cheap source of invert sugars, which can be fed to animals, or fermented to chemicals and biomass. It is also viscous and sticky, so is used as a binder for powders in industrial uses. The vinasse left after ethanol distillation contains pentoses (which serves as a nutrient for the growth of certain microorganisms) and the inorganic salts that were in the original molasses, now concentrated. Filter mud contains calcium carbonate from the reactions of the added lime, and the wax which originally was on the epidermis of the cane. Bagasse contains cellulose fibres in a lignin matrix, which can be used together in boards, or separated in pulp production. A partial hydrolysis can be used to provide a low grade animal feed or a substrate for fungal growth, or the cellulose can be fully hydrolysed (with difficulty) to

provide a solution of sugars, or pyrolysed to produce pyrolysis or producer gases, carbon and pyrolysis oil. Direct combustion of bagasse provides the energy to run the sugar factory, and often a surplus which can be converted to electricity for sale. Cane tops are used as an animal feed, and, in principle, could be a source of leaf protein.

Despite this gamut of possibilities, only a few have been tried on an industrial scale, and even fewer have succeeded. The developing world is full of failed bagasse newsprint mills and particleboard plants, of abandoned cane wax extraction plants and molasses feedlots, of broken down bagasse briquetters and cane separators. How is it that what should, at first sight, be eminently appropriate technologies, by making use of local raw materials, reducing waste, providing local income and employment under local control, and reducing dependence of the area on outside supplies, can adapt so poorly to local conditions that they fail?

Answers to such questions cannot be found in the laboratory. It is necessary to study the industrial implementation of these technologies, in particular in underdeveloped countries. What method should be used to study the industrial utilization of sugarcane by-products in underdeveloped countries? Three approaches might be considered:

- i. A state-of-the-art survey of the technology,
- ii. using cost-benefit analysis to choose technologies, and
- iii. studying the dynamics of the introduction and development of new technologies into a particular society through particular case studies.



The first approach cannot provide answers to the questions asked. For there have also been examples of successes in these same technologies which have failed. Introducing the same technology into different economic and social environments produces different results. Although there have been technologies which failed because of "purely technical" difficulties (e.g. some bagasse briquetters, early cane separation equipment), these have been a minority of cases. Furthermore, as the case study of the Mauritian particleboard plant will show, the machine-embodied concept of technology favoured in state-of-the-art studies\* can lead to the thoughtless "parachuting" of industrial plant into underdeveloped countries and their inevitable failure.

The second approach is typified by the studies produced at the David Livingstone Institute of Overseas Development Studies(16). To summarise very briefly their methodology, take a particular industry, say the production of shoes or ships or sealing wax, split up the production process into unit operations and processes, find out some of the alternative technologies that already are in use, cost them in terms of the labour employed, foreign and local capital and raw materials used, and other costs, and perform a social cost-benefit analysis on each operation or process (their "sub-technologies") to identify which one makes optimum use of the factors of production under a given set of labour and capital costs. Conclusions are then drawn on which of an existing set of assemblies of these "sub-technologies" makes best use of the factors of production, or what

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\* Such as the strictly limited consideration of economic and energetic implications of the use of biomass for energy in the UK in the studies prepared for the Energy Technology Support Unit(15).



combination of "sub-technologies" would make an optimum use of the factors of production.

Such approaches suffer from two basic defects. One is the emphasis on costs and benefits which can be measured in money terms, leading either to ignoring the non-financial factors altogether, or attempts to assign a price to such things as beauty and national unity. This is only a defect when the cost-benefit analysis is considered as the be all and end all of project planning, where decisions are supposed to be taken purely on the basis of economic analysis. Such attempts to impose a technician's analysis on the decision-making process have been roundly condemned by a fellow economist, Hirschman, who commented in this vein:

How could it be expected that it is possible to rank development projects along a single scale by amalgamating all their varied dimensions into a single index when far simpler, everyday choices require the use of individual or collective judgement in the weighing of alternative objectives and in the trade-off between them? There is much to be said, it is true, for facilitating decision making by reducing the many aspects of the project to a few crucial characteristics, one of which would of course be the rate of return. It is one thing to permit, in this way, the decision maker to use informed judgement in making critical choices and trade-offs; it is quite another, however, for the technician to aim at dispensing with such judgement altogether. This aim would be implicit in the submission of a one-dimensional scale to a then obsolete "decision maker". . . . the heavy price for this unique ranking is, in fact, that, with many important considerations excluded from the technicians' purview, the decision maker will in the end make more rather than less use of his intuition and "seat-of-the-pants" judgement than if the technicians has set themselves the more modest goal of comparing projects according to a limited number of criteria(17,pp.179-80).

When used merely as a technique to combine the different economic factors involved, social cost-benefit analysis serves a purpose. For example, it is used in this thesis to assess if a particular technology in one underdeveloped country could be economic in

another, higher wage, country. But, taken alone, this does not imply that this technology would be appropriate to that country.

The second problem in this approach of choice of technology through cost benefit analysis is the static nature of this vision of technology. There is no room for design of new or improved technologies. And technical and social design improvements in projects can have a great effect, as the following account of some World Bank sponsored research into capital-labour substitution in civil construction shows:

In the first phases of this research, labour-intensive methods were found to be technically feasible for a wide range of construction activities, for which they achieved product standards equal to those of more capital-intensive methods, but were also found not to be economically competitive even at extremely low wage rates. However, in subsequent phases of the research, which were carried out in the context of operational projects, it was found that traditional methods can be made economically competitive even at modest wage rates by adapting them through introducing improved tools, proper wage incentives, changed project organization, and more careful management of the work(18).

Such possibilities are, however, ignored in many "choice of technology" studies. As Pickett(16,pp.32-3) says, "The fact that the investment decision is thus rooted in the present and indeed the past and has consequences for the future is, of course, elementary and evident. It is, nevertheless, of great importance and leads directly to significant features which must be recognized in the economic evaluation of projects. . . . This point registered it is largely ignored in what follows."

It is the third approach which has been used to study the industrial utilization of sugarcane by-products. Studies of appropriate and inappropriate technologies have often taken a project (say a dam)

at a particular time, and analysed the social and environmental effects of the project upon the region and the local people as it was at that stage in the history of the project. Others have taken a proposed project, and, by studying what is known about the technology and the environment of the proposed project, attempted to foresee the consequences of the implementation of the project. While these studies are valuable, they are necessarily limited. For projects, technologies and people change with time; e.g. the social effects of a dam on displaced people during construction are different to those when these people are living on the fish in the new lake. To study the interaction of a technology with its economic and social environment it is necessary to study the historical process of their effects upon one another. These effects act in both directions, although not equally. Technologies which are successful, in their own terms, have more effect upon the environment than the reverse; whereas technological failures have often been affected more by the environment.

There have been few studies of the historical development of the introduction of technologies new to a society: perhaps for practical reasons, for few people have the time to study a project over a long timescale. Nevertheless, projects can be visited some years after they were set up, information gathered, and the history of the project, its problems and solutions, successes and failures, can be reconstructed. Such studies have also been rare—one notable exception being Hirschman's "Development projects observed"(17). Hirschman studied the histories of 11 projects which had been funded by the World Bank and had been in operation for several years. These projects, typical of those funded by the World Bank in its early years, were predominantly infrastructural. In his book he tried to systema-

tise his observations on project behaviour, drawing out experiences common to different projects.

His studies were carried out in 1964-5, and show a concern for aspects of project behaviour which later were used by supporters of appropriate technology in their critiques of the standard economic thinking, whereby the selection of only limited, quantifiable, criteria of project analysis had led to the creation of myths such as "economies of scale". One of Hirschman's chapters was entitled "Project appraisal: the centrality of side effects". In it he shows how these so-called side effects can be so important that they can become essential requirements for the survival (let alone success) of the project. His examples include the murder of the West Pakistan manager of a paper mill in what was then East Pakistan as a result of the mere side effect of racial tensions. Similarly, his discussion of positive side effects shows an understanding of the reality of, the constraints of, development. Discussing advice to "pre-take-off" countries he wrote, "for to hand these countries the advice to develop capital-intensive industries is rather like counseling a young man from a poor family who is starting out in life to find himself a wealthy grandfather."#

Hirschman makes a useful distinction between social aspects of these projects. This is in the extent to which they accept existing social behaviour as given (trait-taking), or require a change in social behaviour for their success (trait-making). Certain technologies require the existence of particular social behaviour in order to

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# Some countries do manage to find themselves "wealthy grandfathers". All they need to do is kill peasants and call them communists.

succeed. If these traits are neither present in a society, nor can be created, the technology transfer is doomed to failure. As an example of this, he shows how the Nigerian Railways suffered from inter-tribal conflicts, such that in many areas freight was sent by lorries owned by people of the same ethnic group, rather than the "foreign" railway. For the railways to have been successful would have required a massive change in social values. However, when a project succeeds in introducing a new trait (such as a reduction in corruption), this can be socially beneficial, and permit further development which was not possible given the previously existing trait. From this Hirschman concludes that a project should set out to be neither completely trait-making or trait-taking but set out to be trait-making in only a limited number of ways and then consciously try to promote these changes. He recommended an explicit analysis of this when designing projects. By and large, this recommendation has been ignored.

In his studies of the project histories he came across many examples of problems which had been unforeseen by the actors in the projects, but when they arose the actors surprised themselves by being able to solve them. He suggested that for projects to be attempted, potential difficulties have to be hidden, or potential benefits exaggerated, so that they may be approved by decision makers who lack confidence in their own abilities. Then when the problems arose, the same people find their abilities such that they can overcome these problems, making them more confident in their abilities for the future. Hirschman calls this the "Principle of the Hiding Hand". This is probably the weakest part of his book, since if the project fails due to inadequate preparation for problems that have been deliberately hidden, confidence will be reduced rather than

increased. Blind faith in a promoter's promises is dangerous for those attempting to introduce new technologies to underdeveloped countries. It will be shown in the conclusions how this principle does not apply to the case studies in this thesis, and appears to rest on a mistaken conception of creativity and innovation.

These case studies are of the current usage, and attempts to introduce new uses, of sugarcane by-products in Mauritius. As mentioned previously, it was decided to investigate agricultural by-product utilization on an island; and Mauritius was chosen.

Mauritius is an island in the Indian Ocean (20° 15' S, 57° 31' E), about 800 km to the east of Madagascar, and is approximately 60 km long by 40 km wide, with an area of some 1860 km<sup>2</sup>. Some maps of Mauritius are reproduced in an appendix.

The island, originally uninhabited, was first settled by the Dutch in 1638 but abandoned in 1710. Five years later the French took over, and remained in control until a British task force of 10 000 troops invaded the island in 1810 following a lengthy blockade. The total population of the island was only 70 000 at the time. Under the British the production of sugar, which had started under French rule, was greatly extended, while the African slaves were replaced by Indian "indentured labourers"(19). The subsequent history of the struggle of these workers against exploitation is best outlined in the Durand's book, "L'île Maurice, quelle indépendance?"(20). This gives probably the best outline analysis of the Mauritian economy, society and politics. Other more specific studies of the social anthropology of the Hindu Mauritians have been written by Benedict(21). A notable feature of Mauritian society is that it is

divided not only on class lines, but also ethnically. This affects the politics and extends into decision-making even in private companies. The economy is dominated by a Franco-Mauritian, sugar estate owning, oligarchy, whereas the civil service is dominated by Mauritians of Indian descent. As social interaction between the groups tends to be limited, this leads to a particularist style of decision-making, as for example appointing people on the basis of their connections with the family of the owner, rather than on their ability. This can have serious effects on attempts to introduce new technologies into Mauritius, as it is in exactly these attempts that ability and creativity are most required of the management and workers in an enterprise.

Sugarcane is the predominant crop, occupying 92% of all the cultivated land. Sugar and molasses represent 85% of the exports of the island, after deducting the costs of imported raw materials for every export. In 1978, the added value in sugar production was 24.1% of the total GNP(22). The island is, therefore, highly dependent on the price paid for its sugar, most of which is sold to the EEC under the terms of <sup>the</sup> Lomé Convention. Since the 1974 sugar boom, the income from sugar exports has declined, yet imports had continued at the high level engendered by the money available during the boom. This has led to balance of payments problems, and intervention by the International Monetary Fund, which has twice required the Mauritian government to apply their usual solution to economic problems—devaluation.

This economic situation has encouraged Mauritians to become more concerned about who should suffer the austerity measures, than about alternative development possibilities. The effects of the former may



be seen in a few weeks time (in June, 1982) in the forthcoming Mauritian elections. The latter concern has led more Mauritians to consider diversification from sugar, either by planting other crops (Mauritius imports nearly all its food, including the staple food, rice), or by adding value to the by-products of sugarcane. Among the latter suggestions are proposals by Lonrho to build a distillery to produce ethanol for blending with petrol from molasses, thus saving on imports. This has also been considered as a possibility in a UNIDO sponsored study for the Mauritian Government on the utilization of sugarcane by-products carried out by Booker Agriculture. Meanwhile sugar factories are increasing their production of electricity from bagasse for sale to the Central Electricity Board (CEB).

More general suggestions have been made by Paturau in an article which studied the possibility of integrated development of all the production in a sugar factory area(23), and by Baguant in a thesis on energy strategies for less developed countries(24). Baguant considered the energetic and economic implications of applying the intensive cane cultivation (close-spaced rows) and energy production strategies proposed in the Battelle studies for the USA(25) to Mauritius and Nicaragua. This offers possibilities of reducing the area under sugarcane cultivation while increasing the energy production from the sugarcane. In the simplified model he used, however, he did not allow for the lower sugar contents found in cane grown at closer spacings, or in the trash and tops he proposed would be crushed together with the cane, thus invalidating his calculations of sugar and molasses production. Nevertheless, provided that the long-term soil fertility could be maintained under intensive cultivation, this suggestion might provide a means for Mauritius to have their cake and eat it (at an increased risk).

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\* The combined Mouvement Militant Mauricien and Partie Socialiste Mauricien opposition won 60 out of 62 seats in these elections.



These suggestions, and the previous attempts to utilise sugar-cane by-products, in Mauritius, must be seen in the context of development in a market economy. The Mauritian economy is relatively open, and only recently have exchange control regulations been tightened, following the previously mentioned devaluations. Most industry and commerce is in private hands, as government intervention in industry has, historically, been concerned with the establishment of infrastructure (in the port, airport, water and electricity development), and with incentives for the establishment of new, employment-creating, industries.

Furthermore, the Mauritian economy is a dependent market economy. In market economies power is in the hands of those with the greatest purchasing capacity; in capitalist economies it is in the hands of those with most capital; in monopolist economies power is in the hands of those who control production. In the international market economy, Mauritius is powerless under all three counts.

What is appropriate in such an economy is different from what would be appropriate in a larger, centrally planned economy (such as Egypt). The small size of the island forces it to depend more on international trade than do larger countries, which can produce most of their needs locally. This puts extra constraints on the choice of techniques to be used.

Firstly, consider an exporting industry. It has to sell at international prices (in the absence of a regional market, or special trade agreements), at quality levels set by international competitors. Any search for an appropriate technology for an export industry\* is constrained by these requirements. Designs can be developed

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\* Or one which produces inputs for an export industry.

which maximise employment creation, and the use of local resources, only to these limits. Technologies used in export industries may be inappropriate in two ways. Either the product of this technology is internationally uncompetitive (in which case, the enterprise fails), or, in order to compete internationally, it requires too great an exploitation of Mauritian resources (the workers, the physical environment, foreign exchange) to be socially acceptable.# Sometimes, local conditions and external constraints may combine to leave no possibility of designing a technology which could overcome them, in which case the industry is inappropriate. An example of this is the production of bakers yeast for export, studied in chapter 4.

On the other hand, industries producing for the local market are also constrained by world market conditions, as, given the import dependence of the Mauritian economy, they will be substituting for imports. In the absence of government intervention, they have to be competitive with imported products†, and the above comments apply.

An appropriate technology for development, in such circumstances, will have to accept the constraints of the **world** market economy, but attempt to reduce economic and technological dependence, and the underdevelopment resulting from past and present exploitation of such peripheral economies, by making better use of Mauritian resources. These resources may be "factors of production" or "social traits". The **local** market economy, on the other hand, need not always be taken as an absolute limitation on the selection and design of technology. Some aspects have to be accepted, others can be fought against through government or private action.

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# When compared with alternative technologies.

† Although now the high freight costs will be in the favour of the Mauritian producers.

For instance, historically the Mauritian Government has intervened to support new industries, in furtherance of its policies of employment creation, establishing new manufacturing industries, and improving the income distribution(26). This it has done by providing incentives in the form of tax relief and, sometimes, import controls, for Development Certificate and Export Processing Zone companies. To this end, they have applied social cost-benefit analysis to government projects, taking into account the benefits to the national economy of employing previously unemployed people and saving on foreign exchange(27). These methods have been applied to the Indian technologies of paper production in mini-mills and handmade paper plants, to see if they might be economically appropriate under Mauritian conditions. This is necessary, but not sufficient, however, to determine the appropriateness of these technologies in Mauritius, because of the limitations of social cost-benefit analysis mentioned previously, especially as regards those resources which are better described as social traits rather than factors of production.

Such traits of Mauritian society are described in the work of Benedict(21) and Durand(20), and in the cases studied here. Some of these arise from the power relationships inherent in a small, monoculture, import dependent, market economy. For example, consider the effects of purchasing power upon marketing. Those who purchase large quantities of a product have more influence upon a producer than many small, dispersed, consumers. Predicable consequences are:

- i. A dispersed group of consumers, each purchasing a small proportion of the output of a factory will have less influence on the type and quality of goods produced than a few, large consumers,
- ii. and a few wholesalers may be more visible to a producer than many small consumers, and, therefore, have more influence over

the producers decision-making, despite the producers long-term interest in satisfying the consumer.

These, and other, traits of Mauritian society have to be taken into account in the design of appropriate technologies—some as design constraints (trait-taking), some to be changed (trait-making). But which should be accepted, which changed? To understand this, it is necessary to study the history of interaction between the technology and its social environment (including the market economy). This is done in chapters three, four and five, where a bagasse-based particleboard factory, an active dried bakers yeast factory, and cane spirit production are analysed.

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## CHAPTER TWO

### Survey of technical literature

The purpose of this section is to survey of the appropriate and inappropriate technologies which have been used to upgrade sugarcane by-products at a factory scale. Much of the extensive literature on sugarcane by-product use describes laboratory experiments which have not been tested on an industrial scale. The difference between laboratory possibilities and practical realization are such that many suggested techniques fail. Such untried techniques cannot, at present, form the basis of a development policy of upgrading agricultural wastes to provide added value in rural areas. Rather they can be considered as starting points for long term research programmes in institutions such as local universities. For such research work there already exist excellent bibliographies on the subject.

Indeed, each year the Sugar Milling Research Institute at the University of Natal produces a definitive bibliography on "The industrial utilisation of sugar and mill by-products", prepared by Maurice J. Kort<sup>†</sup>(1). Apart from the by-products themselves, this literature survey also covers the related topics of livestock feeding, industrial uses of refined sugar, developments in sucrochemistry, nutri-

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<sup>†</sup> Available from the Sugar Milling Research Institute, Univ. of Natal, Durban 4001, South Africa.



tion and toxicology, and other sweeteners. Its references are taken from the scientific and trade journals, patents, conferences and symposia on sugar technology and related fields, and from books. In the May 1980 edition, 58 pages were devoted to by-products from sugar manufacture and another 32 to livestock feeding with 688 and 340 references respectively. Kort gives the following summary of the subjects covered in the literature for that year:

Predictably, much attention is being paid to the very topical fermentation of cane and its by-products to fuel alcohol. From the references given in this and previous reports in this series, it can be seen that the technology is known but that it still revolves around economics and politics. Indeed, the Government of South Africa is urged to clarify its thinking on the production of fuel alcohol from cane (Refs. 475 to 477 and 479 to 481, Chapter 1).

Besides alcohol, various other compounds can be obtained from cane by-products by fermentation, for example yeast, protein, acetic, citric, glutamic and other acids, acetone, butanol, antibiotics, methane and many more. In addition, furfural, cellulose and monosaccharides can be obtained from bagasse. A look at the Index to Chapter 1 (page 2) will show that factory and distillery waste water, filter mud, molasses and bagasse find many other applications in addition to their use as substrates for chemicals and in livestock feeding. Other by-products used in livestock feeding and detailed in Chapter 2 are cane, cane tops and juice, yeasts and sucrochemicals as well as beet and beet pulp. These by-products can, therefore, contribute substantially to the economics of sugar milling.

This "Index to Chapter 1", together with the same for Chapter 2, is reproduced in figure 2.1. These indicate the comprehensive nature of this literature survey. This survey of technology in no way attempts to duplicate Kort's excellent bibliography. The reader is advised to consult Kort if he wishes to explore the comprehensive literature on the use of specific by-products.

As no bibliography or review can be complete (although that of Kort very nearly is), other reviews, literature surveys and bibliographies will be mentioned. Furthermore, the bibliography to

Figure 2.1 Indexes to chapters 1 and 2 of Kort(1)

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(b) Fertiliser . . . . .	3
(c) Industrial uses . . . . .	4
(3) Filter Mud . . . . .	4
(a) General . . . . .	5
(b) Calcium carbonate and lime recovery . . . . .	5
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(a) Using Molasses . . . . .	60
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(e) Using Sugarcane and Cane Tops . . . . .	73
(f) Using Cane Juice . . . . .	75
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(h) Using Yeasts . . . . .	76
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this thesis is available in computer readable form from the author and the Department of Electrical Engineering of the University of Edinburgh, and in a version which is already indexed for use on computers running the the UNIX\* operating system . In this form searches may be based on multiple keywords.# A more extensive on-line database on sugar and energy can be consulted at Tate & Lyle Group Research and Development's library at Reading.

For a description of, and introduction to, the technology of the utilization of sugarcane by-products, the reader is referred to the now standard text on the subject, "By-products of the cane sugar industry", by J. Maurice Paturau(2). This gives the state-of-the-art in 1969 on all the uses of sugarcane by-products. The range of the uses described is shown in figure 2.2, taken from Paturau's book. The processes used to convert the by-products into these products are described, together with the technical advantages and disadvantages of each process and the production economics when known.

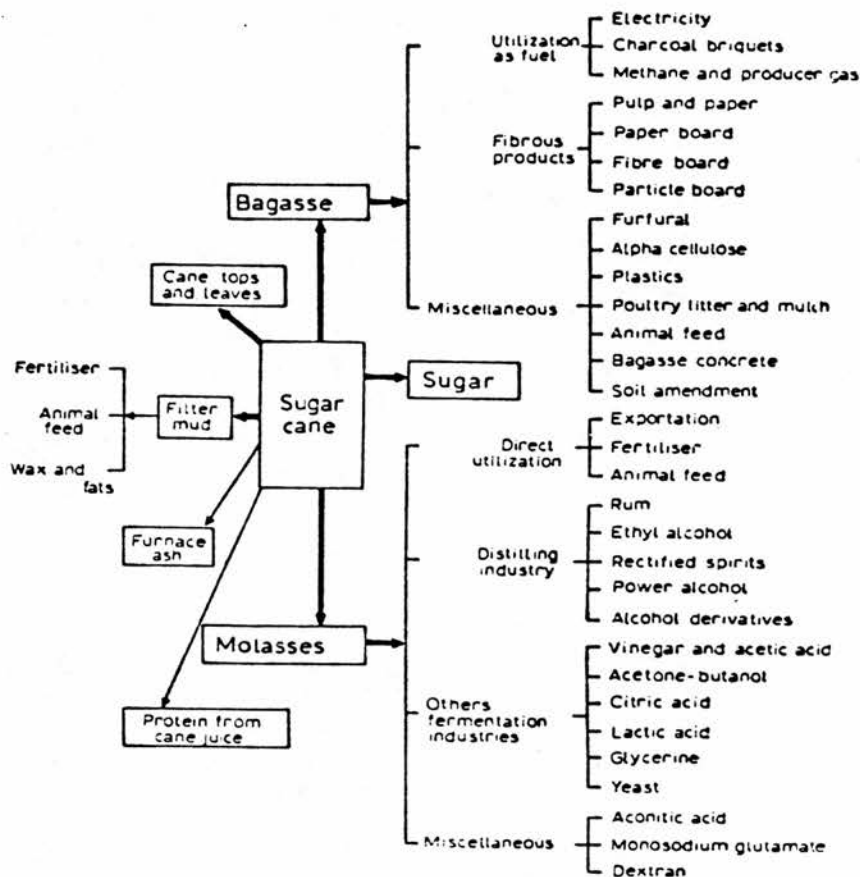
No attempt has been made here to describe technologies already described in Paturau, and it shall be assumed that any reader unfamiliar with such technologies will consult Paturau's book. From this starting point, in 1969, the present survey will concentrate on developments which have been tried on an industrial scale, since 1969. Particular attention has been paid to the range of alternative technologies available; a point often ignored in reviews on the subject, which often consider only the largest scale technologies for any given end. Particular stress has been placed on articles which

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\*UNIX is a Trademark of Bell Laboratories.

# And so rendering technologically obsolete the references in literature surveys which merely list straightforward, unimportant, articles that are not worth discussing.

Figure 2.2 By-products of the cane sugar industry (from Paturau(2) p.8).



provide information which may be used to assess the appropriateness of a technology to specific material conditions. A particularly important subset of these are case studies of existing plants (or, failing these, project proposals). Whenever sufficiently detailed case studies have been publicly available, they have been critically discussed in the appropriate chapters of this thesis. Therefore, much of the discussion of the literature on the production of particle-board, pulp and paper, yeast and cane spirits will be found in the chapters on these subjects.

## 1. General use of sugarcane by-products.

In this section are described works which consider the use of

more than one by-product, or the production of several different products. Some of these are summary papers published at conferences, some are studies of the existing or potential industries relevant to a particular country, others integrate a variety of processes under a common theme such as energy.

First should be mentioned the Mauritius Sugar Industry Research Institute (MSIRI) Technical Circular No. 18, "By-Products of the Sugar Industry of Mauritius"(3), which Paturau later developed into his book on the subject. Apart from a substantial review of the technology and the data on Mauritian availability of bagasse, molasses, filter mud, and cane tops, it includes the history of the use or attempted use of each by-product in Mauritius. The histories of the production of rum and alcohol and of attempts to produce paper are described in later chapters of this thesis.

Another early study was one prepared by Freeland(4) for the Pakistan Industrial Credit and Investment Corporation. This was on a US Agency for International Development contract to advise what use might be made of by-products in Pakistan at that time, based on Freeland's experience in Taiwan. He gave estimates for the surplus bagasse at each mill (very low except at the largest mills), molasses production and use. In the then East Pakistan (now Bangladesh), most of the molasses was used in tobacco curing for its flavour. In West Pakistan only a few mills produced alcohol, always for potable spirits. He recommend that some proposals by factories in West Pakistan to set up industrial ethanol distilleries be supported, at least one of which, at Crescent Sugar Mills, Lyallpur, was built. He described the Taiwanese processes to produce acetic acid by submerged fermentation, Torula yeast, monosodium glutamate, bagasse pulp, hardboard and

insulation board, and particleboard, giving 1962 Taiwanese prices where available. It is interesting to note that the technologies for these processes were developed in Taiwan, not imported. So when present-day reviewers on the use of sugarcane by-products claim that certain processes are secret or patented and too complicated to develop in a Third World country without buying a turnkey plant or at least licensing a process, it is not strictly true, as the Taiwan example showed. Indeed, the latest advances in any technology are not easily rediscovered independently, but for countries with an advance educational level self-design is possible, if not in the original plant, then in designing improvements. For example, the Egyptian staff at the Hawamdieh acetone-butanol distillery had improved the original Russian fermentation process to reduce the number of fermentations lost through infection and adapt the process to their feedstock of molasses (the Russians used potatoes).†

Tedjowahjono(5) described the present uses of sugarcane by-products in Indonesia and prospects for developing this industry. Four of the 61 sugar factories have distilleries, three produce cane spirit and industrial ethanol (at Palimanan, Comal and Madukismo), the other only produces cane spirit (at Jatiroto). The PT Madubaru also raises cattle using molasses and cane tops as fodder. Four companies outside the sugar industry also make alcohol from molasses, PT Asen Pabuaran, PT Madu Sari, PT Air Matu Ibu and PT Padaharja. PT Sasa Inti, PT Ajinomoto Indonesia and PT Miwan produce monosodium glutamate (MSG) from molasses. PT Sumbar Protein produces fodder yeast from molasses, and, finally, PN Kertas Letjes had launched an

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† Personal communication by laboratory staff to the author during a visit in June 1976.

expansion of its paper factory in order to use bagasse as a raw material.

The typical yield of ethanol in Indonesia was 250 l(at 95%)/t molasses. A new distillery imported from Australia would have cost Rp 2G including installation for a 15 000 l/day plant. Molasses at Java cost Rs 30 950/t (US\$49.36/t), while the alcohol produced sold for Rp 232/l (US\$0.37/l) at the factory (fixed 3 May 1979), which after the addition of taxes, storage, transport and other charges raised the price to Rp 481.75/l ethanol or Rp 326.72/l cane spirit, f.o.b. at a port city.

The fodder yeast factory produced 4-6 t/day and planned to increase the capacity to 8t/day by the end of 1980. The company had built its own fermenters and bought a molasses clarifier, yeast separator, yeast drier, boiler, and diesel generator. They were selling this fodder yeast in May 1979 for Rp 220/kg (US\$0.35/kg).

Of the three factories producing MSG, one produced 240 t of glutamic acid and 160 t of MSG monthly (PT Sasa Inti), PT Miwon Indonesia produced 120-150 t/month glutamic acid and PT Ajinomoto Indonesia was capable of producing 400 t/month MSG, at a yield of 1 t MSG from 6-7 t molasses. (cf. theoretical maximum of 1 t MSG from 4 t molasses). The retail price of MSG in Indonesia was Rp 2000/kg (US\$3.2/kg).

Indonesia had exported paper to India at the end of 1979 for the first time, and had received enquiries from Malaysia, Hong Kong and Singapore. So the PN Kertas Letjes pulp and paper factory was planning to start construction of a 180 t/day bagasse pulp line in 1980, planned to enter production in 1983. The article did not mention



which pulping process would be used, only that the yield would be 1 t pulp from 3.64 t dry wt. bagasse. The bagasse would be blended with other pulp to produce 260 t/day paper.

Tedjowahjono also reported on the possibilities of producing pellets from dried cane tops. Indonesian research at BP3G had measured cane top production at 4-20 t/ha (at 70% moisture). Each tonne of tops could produce 0.325 t pellets (at 10% moisture), which could be sold for animal feed. Elephant grass pellets were selling in Lamongan for Rp 40/kg (US\$0.06/kg).

An account of the existing by-product industries in Cuba was given by Noa Silverio in the 15th anniversary issue of the ICIDCA journal(6). He gave a summary of the development of historical development of the by-product industries in Cuba, and listed the existing plants in 1980. This table is reproduced as figure 2.3. Note that no wax has been produced since 1964. Before the revolution crude wax used to be exported to Louisiana where it was refined. Pilot production of semirefined wax based on studies at ICIDCA (Instituto Cubano de Industrialisation de Derivados de Cana de Azucar) will begin at the Jesús Menéndez sugar factory.

Andrews has given an overview of the by-products industry in South Africa(7). Figure 2.4 gives his list of the South African sugar mills with their by-product production. Many by-product using factories in South Africa are away from the mills, and closer to the markets, with the exception of those that use bagasse.

Andrews outlined the difficulties of producing paper from bagasse in South Africa and competing with locally produced wood based paper. As a result, there are no independent bagasse pulp

Figure 2.3 By-product utilization plants in Cuba, 1980

Tipo de planta	Nombre de la planta	Capacidad tm/año
Tableros de partículas	Pro-Cuba	18 000
" " "	Maderas Técnicas	9 000
" " fibras	Primadera	10 000
" " "	Henetex	3 000
Pulpa y Papel	Pulpa Cuba	18 000 (pulpa)
" " "	"	30 000 (papel)
" " "	Técnica Cubana	13 500 (pulpa)
" " "	"	27 000 (papel)
" " "	Papelera Damují	13 500 (pulpa)
" " "	"	21 000 (papel)
Levadura torula	Planta de Pina, Morón	8 000
" " "	Antonio Sánchez, Cienf.	12 000
Levadura sacharomyces	Héctor Molina	1 120
" " "	José A. Echevarría	2 520
" " "	Melanio Hernández	1 120
" " "	Enrique Varona	1 120
" " "	Amancio Rodríguez	1 680
" " "	TOTAL	7 560
Dextrana	Planta del Central España	350
Alcohol etílico	Abraham Lincoln	156 800 HI
" " "	Héctor Molina	156 800 "
" " "	Santa Cruz	168 000 "
" " "	José A. Echevarría	280 000 "
" " "	Melanio Hernández	156 800 "
" " "	Enrique Varona	156 800 "
" " "	Amancio Rodríguez	156 800 "
" " "	TOTAL	1 123 000 "
Plantas miel-urea-bagacillo		195 000
Bagacillo Predigerido		23 000
Cera Cruda	Brasil	1 200*
" " "	A. Guiteras	2 000*
Cera cruda y refinada	Jesús Menéndez	2 000* (300 tm de cera semirefinada)

Tableros = board. Levadura = yeast. Miel = molasses. Predigerido = pre-digested. Cera = wax. Source: Noa Silverio(6).

plants, all the factories produce high value grades of paper from their bagasse, taking advantage of the specific properties of bagasse pulp. There are mills with capacities to produce 200 t/d fluting paper, 138 t/d bleached pulp for coated paper, and 17 kt/a tissues and toilet paper.

South Africa has its very own failed bagasse particleboard plant, Hulskane Ltd., which entered production in 1972 and was "moth-balled" in 1975. Designed to produce 120 t/d of 9 mm to 50 mm

Figure 2.4 South African sugar mills and their attached by-product uses.

Mill	Company	Sugar Group	Crushing Rate*	By-Product
Malelane	Transvaalse Suiker Korporasie Bpk	—	268	Particle board *
Pongola	Pongola Sugar Milling Co. Ltd	C.G. Smith Sugar	196	— *
Umfolozo	Umfolozo Co-Op Sugar Planters Ltd	—	233	—
Empangeni	Hulett's Corporation Ltd	Hulett's	220	—
Felixton	Hulett's Corporation Ltd	Hulett's	182	Fluting paper
Entumeni	Entumeni Sugar Milling Co (Pty) Ltd	—	54	— *
Amatikulu	Hulett's Corporation Ltd	Hulett's	370	Particle board
Glendale	Glendale Sugar Millers (Pty) Ltd	Loerho	50	—
Darnall	Hulett's Corporation Ltd	Hulett's	263	—
Gledhow	Gledhow Sugar Co. Ltd	C.G. Smith Sugar	268	Coated paper *
Melville	Melville Sugar Estates	—	80	Molasses feeds
Jaagbaan	Noodsberg Sugar Co. Ltd	Tate & Lyle	224	—
Dalton	The Union Co-Op Bark & Sugar Co. Ltd	—	106	—
Tongaat	Tongaat Sugar (Pty) Ltd	—	310	Molasses feeds
Mount Edgecombe	Hulett's Corporation Ltd	Hulett's	212	—
Illovo	Illovo Sugar Estates Ltd	Tate & Lyle	145	—
Sezela	Reynolds Bros Ltd	C.G. Smith Sugar	340	Furfural *
Umzimkulu	The Umzimkulu Sugar Co Ltd	C.G. Smith Sugar	202	—

\* Tons/hour; + Refineries.  
Source: South African Sugar Association.

Source: Andrews(7).

board it had difficulties competing with wood-based particleboard in a 120 kt/a market. However, in 1974 another bagasse particleboard plant was set up by a large furniture organisation. This produced continuous particleboard of 3 mm to 9 mm thickness.

A 5000 t/d furfural plant was set up at Sezela by Smithchem (Pty.) Ltd., and has since been expanded. Most of the furfural is exported.

Molasses is fermented by two companies: to industrial ethanol, carbon dioxide and furfural by Natal Cane By-Products at Merebank, Durban; and to these products and also acetic acid, acetone and butanol by National Chemical Products Ltd. at Germiston and Umgeni. They have faced increasingly severe problems of scaling in the stills and competition from synthetic ethanol and wine spirit. One factory evaporates its vinasse to make an animal feed supplement, the other uses part of its vinasse for fodder yeast production.

Wet bakers yeast is produced by four companies, and dried yeast by two, all of them in urban areas. 4000 t/a food yeast is produced by the Food Yeast Co. Ltd. (a subsidiary of Natal Cane By-Products Ltd.).

Molasses is used by feed compounders at 5% to 7.5% of the feed, and is used as the basis of liquid concentrate feeds, and a small quantity of dry molasses feeds (spray dried or incorporated in meals).

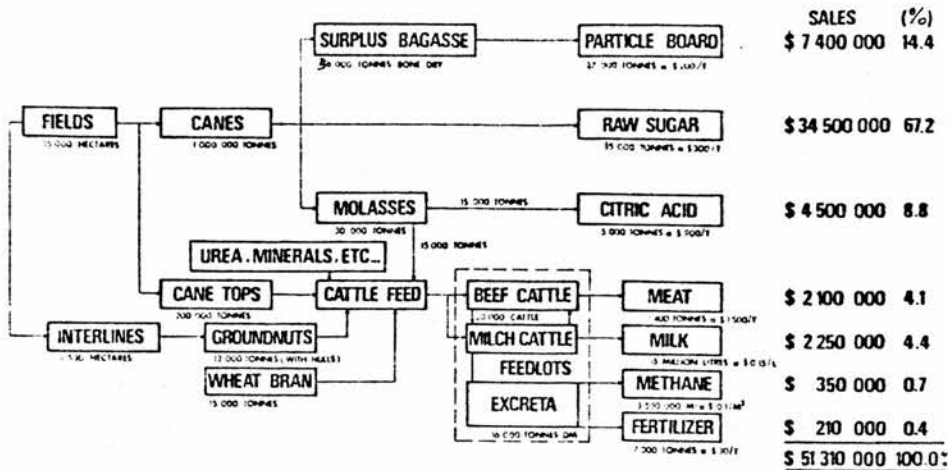
Other country-based studies have concentrated on only certain use of sugarcane by-products. Proenza et al. have produced a study for Jamaica, funded by the Organization of American States (OAS)(8). They were commissioned specifically to report on the potential for the production of pulp and paper from bagasse, animal feed and ethanol. The pulp and paper case study is analysed in depth, and contrasted with mini-paper mills in India, in a later chapter. After a gloomy survey of the Jamaican economy (unemployment rate about 21.5%, 27% of the income received by 5% of the population and 20% of the population received only 5% of the income, growing balance of payments deficit of US\$313.9 M in 1976), they study the sugar industry. The only use of by-products in Jamaica with a large added value was rum production. Their conclusions on all the by-products they studied were negative. In the case of the pulp and paper study they concluded that the market was too small to support a chemical pulp mill, dismissing Indian successes at this out of hand. Their proposed chemimechanical pulp mill could not produce high value printing and writing paper grades, and turned out to be uneconomic unless a 20% import duty were placed on paper. Their proposed feed compounding mill similarly suffered from being defined a priori as a central unit, rather

than using the small, simple, molasses blender designed by Lim Fat in Mauritius.

Several authors have written more general surveys of by-product utilization. Almazán del Olmo(9) and Duguid and Alpine(10) presented papers at the Joint UNEP/UNIDO seminar on the implication of technology choice in the African sugar industry. Almazán del Olmo gave a brief resumé of the uses of by-products, based on Cuban experience. The paper includes tables on the relative production of the different by-products, cane top composition, the composition of a typical Cuban cane top meal, amino acid analyses of the cane tops sugarcane juice and and filter mud proteins, Cuban bagasse, molasses and filter mud compositions, and the composition of pith/molasses feed mixtures. As Cuba has been recently investing in by-product industries, the economic data that he gives may be of some interest. All prices are 1977 ones. A plant to produce 45 kt of writing and printing papers plus 15 kt of tissue papers annually would have cost US\$75-80 M. The production cost would have been US\$350/t to produce paper worth US\$600/t. A particleboard plant of 120 t/d capacity cost approximately US\$13.5 M with a production cost of US\$180/m<sup>3</sup> of board. A Torula yeast plant of 12 kt/a capacity cost about US\$9 M, with a production cost of US\$170/t with molasses costed at the low Cuban price of US\$5/t. Cuba was planning to build ten new plants for food yeast production from molasses to produce 150 kt/a by 1979. For a citric acid plant of 5000 t/a the production cost would have been between US\$450-500/t for a chemical whose maximum world price reached US\$1200. This plant would have cost US\$9 M. L-lysine production at 5000 t/a would have cost US\$24M and US\$1800/t, and sold for US\$8000/t in the main consuming countries of Japan, the USA, France and the UK.



Figure 2.6 Example of thorough utilization of cane sugar by-products.



Source: Paturau(12).

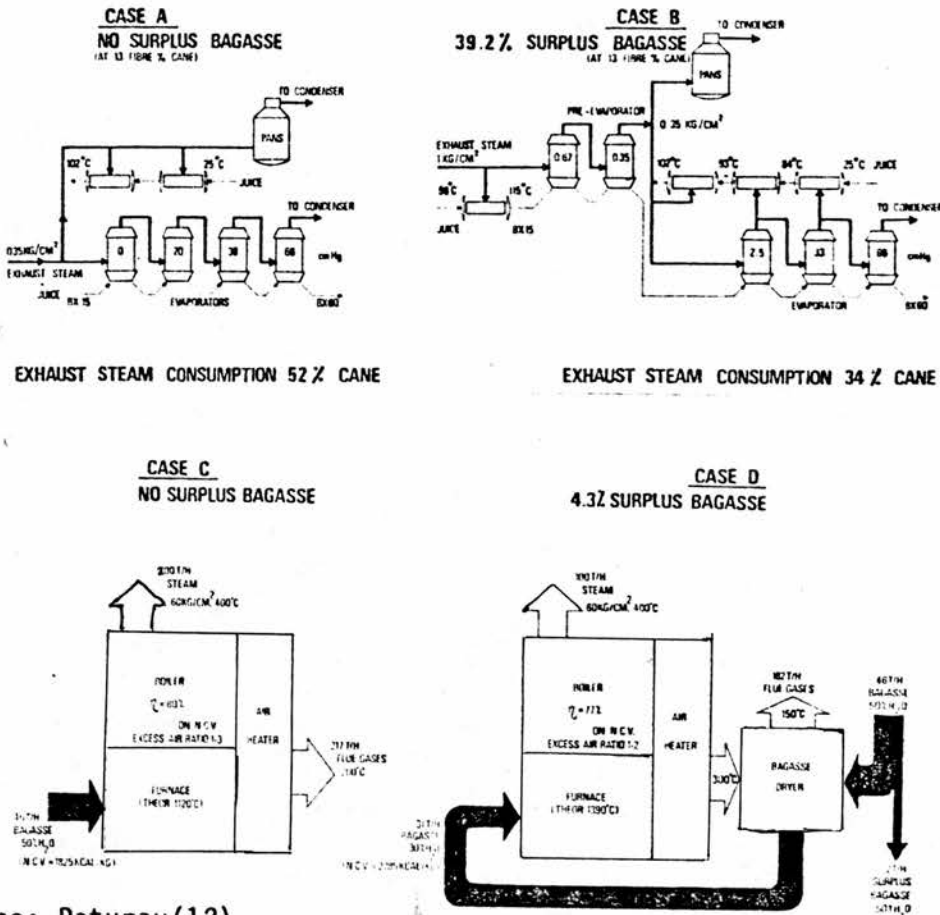
30 000 tons of molasses (worth \$1.05 million) than it is to find a buyer for 10 000 tons of citric acid (worth \$13.3 million)(12).

In his considerations of the uses of surplus bagasse, and the production of energy from sugar factories he has studied the possibilities of economising on steam usage by boiling house rearrangement and bagasse drying by the flue gases (see figure 2.7). He pointed out also that surplus bagasse is not a myth in a well run sugar factory, giving the example of Taiwan where 40% of the total bagasse is saved and made available for the paper and board industries.

Only in his assumptions on minimum economic scales for each process can he be criticised, for no minimum applies everywhere, as the success of small scale alcohol plants in the USA and a microdistillery in Brasil(13) show. Nevertheless, his cost estimates for the different industries using bagasse or molasses (see figure 2.8) are useful for parts of the world where there are large sugar factories or a close grouping of medium size factories.

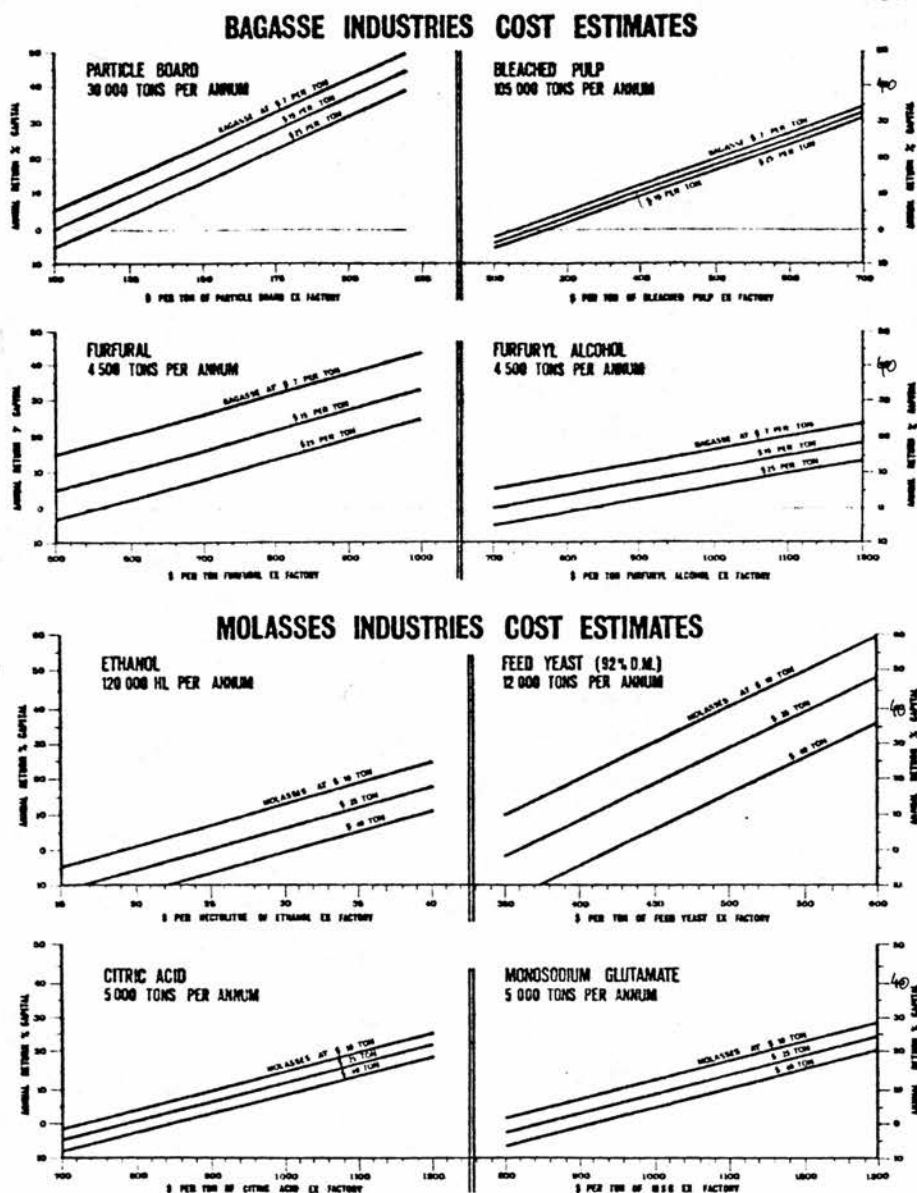


Figure 2.7 Possible fuel economising measures in sugar factories, leading to bagasse saving or electricity production possibilities.



The final group of references to be considered in this general section are on the use of sugarcane as a source of various fuels. Notable among these for their detail are the series of studies carried out at Battelle Laboratories(14,15,16). These consider the potential of sugarcane, sugar beet and sweet sorghum as sources of fuels and chemicals for the USA. The principal products considered were ethanol, acetic acid, butanol, furfural, methane, synthesis gas, methanol and ammonia. The conversion methods studied were ethanolic fermentation, anaerobic digestion, acetone-butanol fermentation, hydrolysis, and several pyrolytic or controlled oxidation processes for producing synthesis gas, including the Purox, Pullman Kellogg

Figure 2.8 Paturau's cost estimates.



Source: Paturau(12)

molten salt, Bailie, CO<sub>2</sub> acceptor, Syngas Recycling Corp. and Fischer-Tropsch processes. They concluded that ethanol from fermentation would cost about the same as ethanol from petrochemicals by 1980, i.e. they would compete in the industrial chemicals market but the ethanol would not be cheap enough to use as a fuel. They thought ammonia could be produced at US\$210-57/t which was not competitive with ammonia produced from natural gas, but which they thought might

be competitive with ammonia produced from coal. As they explain, these synthesis gas processes had been developed for use with coal or municipal solid waste, so there would be development problems caused by the high moisture content and physical form of the bagasse. Another problem not mentioned is that none of these synthesis processes have yet succeeded in producing a gas from agricultural wastes that is clean enough to be used in a methanol shift reactor(17). These processes were all costed at scales of 1000-2000 t/d of dry bagasse feed, which is the total bagasse production of a 330-660 t cane/h sugar factory. Hence they are of dubious application to those areas in developing countries where the factories are smaller and not concentrated in certain areas. Only in areas where sugar plantations are carved out of virgin lands or in a few islands which suffer from sugar monoculture might such quantities of bagasse be obtainable.

One interesting feature of these reports is that Lipinsky et al brought out the effects of applying changes to the agronomic practices on the energy yields. Close row cultivation trials had increased annual yields of cane from 130.5 t/ha to 250 t/ha in Hawaii, and doubled yields in Louisiana. This was achieved by reducing normal cane interline spacings from 1.5 m to 1 m or even 1/3 m, and increasing the irrigation and fertilization accordingly. Sugar contents tended to decrease, but if the cane is being grown as a source of fibre for energy this is less important.

These issues will be discussed further in the conclusions, as Baguant has calculated some of the effects of applying these technologies in different countries(18). In his thesis he developed an aggregate energy demand model to apply it to the USA, West Germany,

Brasil, Nicaragua and Mauritius, and then checks to see how well the predicted shortfalls in energy can be met by applying the ethanol, electricity and ammonia production systems proposed by the Battelle team.

## 2. Molasses utilization

Apart from Paturau's book, there are two other general surveys of molasses utilization. One is a handbook produced by the United Molasses Company(19), on the "Composition, properties and uses of molasses and related products". This provides data on the compositions of different molasses, on their physical properties and their energy values, and a general overview of molasses use in animal feeding and fermentation. This overview does not, in general, provide specific process information, nor does it provide any economic information.

The other survey, "Molasses Utilization" by P. Rüter, (20) was prepared for " . . . policy-makers, planners, development corporations and potential investors, to help them decide on the most appropriate use of this valuable byproduct." This review of the literature covers the composition of molasses, its use in animal feeding, desugarization of molasses, and its use in fermentation to: baker's yeast, food and feed yeast, fat yeast, ethanol and its derivatives and by-products, rum, acetic, citric, lactic, glutamic, itaconic, aconitic, fumaric, malic, butyric, propionic, gluconic and oxalic acids, butanol, acetone, 2,3-butylene glycol, and glycerol. The products and by-products of a molasses distillery are shown in figure 2.9, taken from Rüter.

In a country-related study, Wahab(22) wrote a survey of actual



were used in the rayon production.

## 2.1. Ethanol from molasses.

This has undoubtedly become the most fashionable sugarcane by-product use, as more and more countries around the world are persuaded to set up alcohol distilleries for use as a motor fuel. An article in "la Industria Azucarera"(23) gave a summary of the then known alcohol distillery projects around the world. These were to be built in Fiji, Brasil, the Philippines, Kenya, Yugoslavia, Hawaii, South Africa, and Colombia. Studies were being carried out in Australia, Greece, the USA, and New Zealand.

A bibliography with 831 references has been produced on the subject, Gonçalves, "Bibliographia: Alcool"(24).★ A more specialised bibliography, on the production of alcohol from cassava has been produced by CEDIMO in Moçambique(25) #

There have been several reviews of, and conferences on, this subject, three of which will be mentioned here as they are particularly concerned with ethanol production in developing countries. The World Bank has published a report entitled "Alcohol Production from Biomass in the Developing Countries"(26). This is primarily an economic evaluation of the costs of alcohol production from sugarcane, cassava, molasses and maize, based on Brazilian data. Little attention is paid to more energy efficient processes, or continuous fermentation, which are now commercially available in Europe, but less well known on the other side of the Atlantic. Figure 2.10 shows

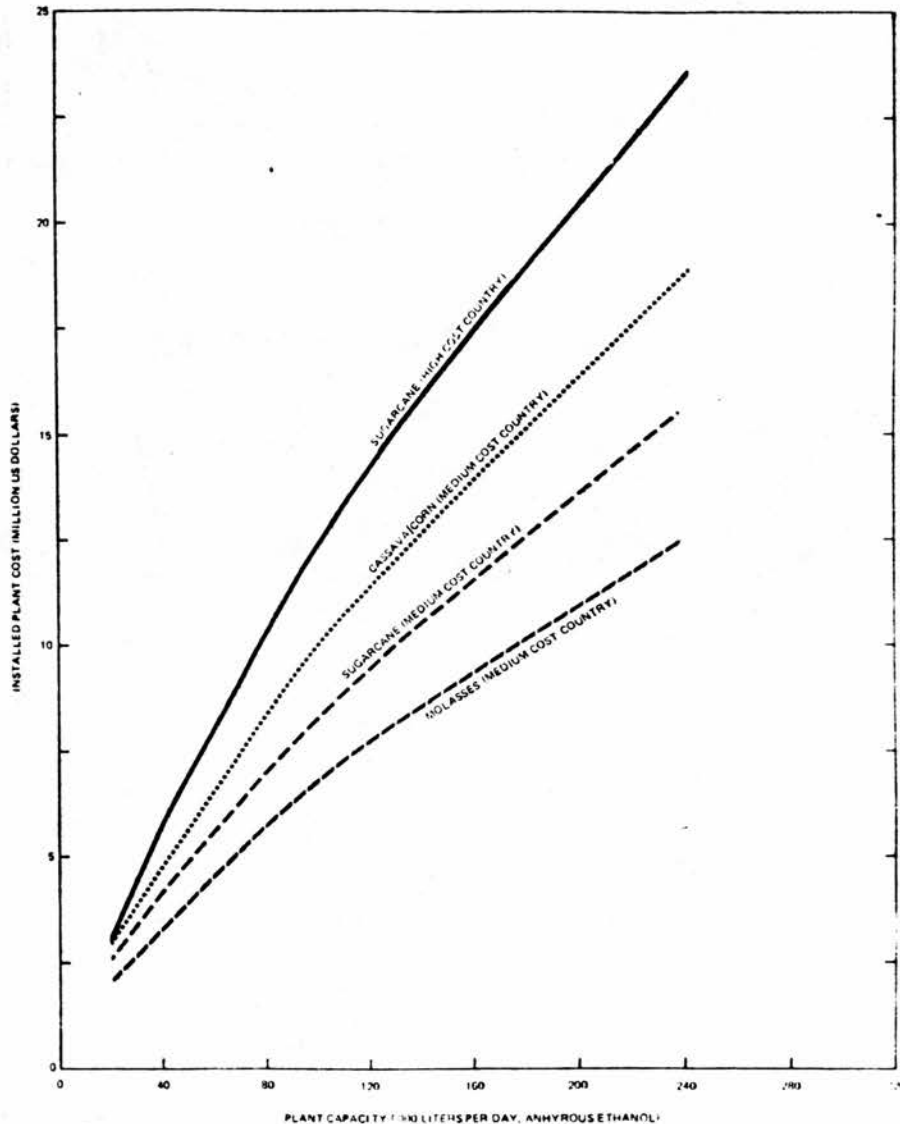
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\* Available from Instituto de Açúcar e do Alcool, CP 420, Rio de Janeiro, Brasil.

# Available from Centro de Documentação e Informação do Banco de Moçambique, CP 423, Maputo, Moçambique.

their guide to the capital costs of ethanol plants at late 1979 prices, and figure 2.11 their estimates for the economic rates of return at different molasses prices.

Figure 2.10 Estimated late 1979 capital costs of ethanol plants

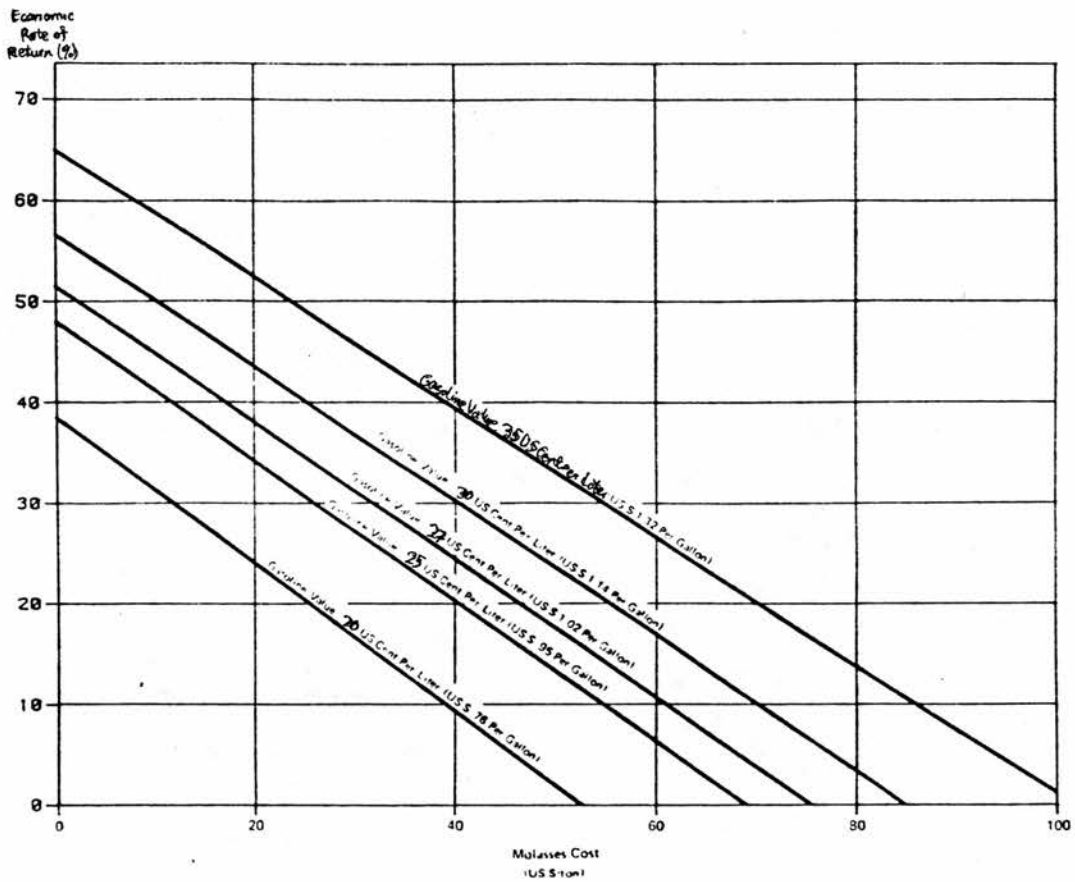


Source: Alcohol production from biomass in developing countries(26).

They suggest that countries with agricultural surpluses and energy deficits are more likely to invest in biomass ethanol production than others, which is a more logical supposition than the more common attempts to relate this to energy use per capita and per caput GNP.



Figure 2.11 World Bank estimates for 120 kl/d ethanol from molasses.



Source: Alcohol production from biomass in developing countries(26).

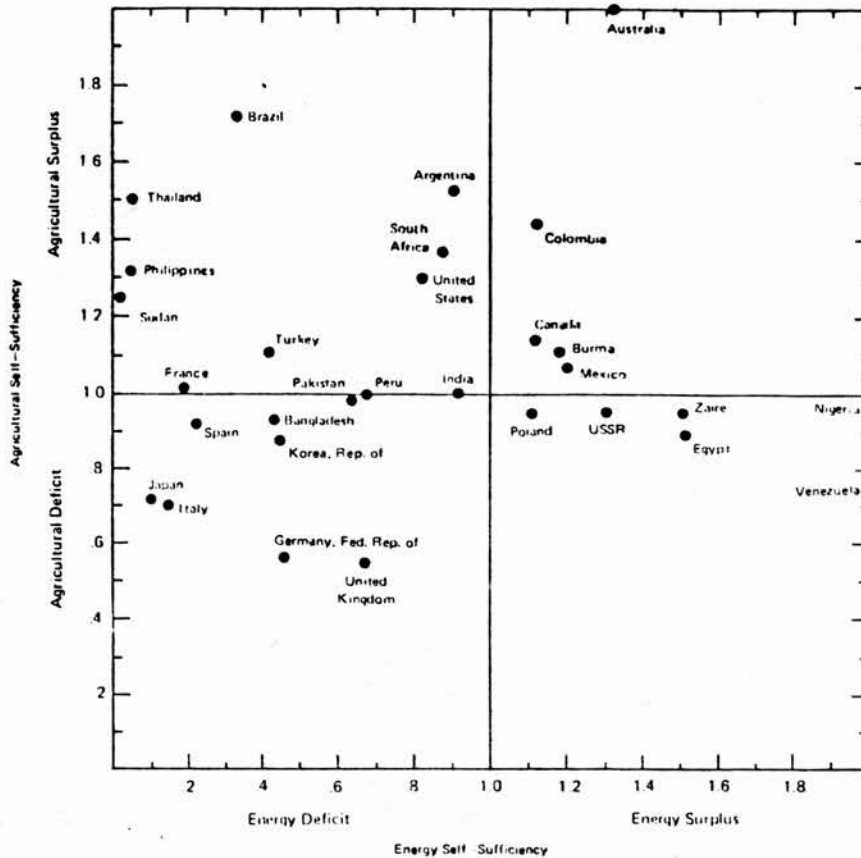
As a guide they provide a figure showing these ratios for a number of countries (see figure 2.12).

The OECD Development Centre organised a meeting of "experts" on molasses and industrial alcohol in December 1976 for a French businessman, M. Pierre Mariotte, whose company SOFECIA† traded in molasses and alcohol. His support for this meeting was the outcome of a synthesis between his professional interests and his concern for the impact of the energy crisis on the developing countries.‡ Many of

† Société Financière d'Entrepôtage et de Commerce International de l'Alcool.

‡ As he wrote in a letter to the author in June 1977, "Il est vrai que je m'intéresse pour des fins très précises à l'utilisation des produits végétaux pouvant être distillés et

Figure 2.12 Energy and agricultural self-sufficiency ratios.



Source: Alcohol production from biomass in the developing countries(26), p.51

the papers presented at this meeting made brave attempts to estimate the trade in molasses and alcohol, worldwide and in specific countries. Those present estimated that by the 1980s there would be a world demand for some 90-105 Mt of sugar which would supply some 30 Mt of molasses. Of the about 27 Mt molasses produced in 1975/76, about 12 Mt were used in the US, Japanese and EEC markets with the balance of 15 Mt used or wasted in the producer countries. The international alcohol market was some 0.5-0.6 Gt or 5-6% of a total world

transformées en alcool afin de permettre aux pays en voie de développement d'avoir des sources d'énergie et ceci même si le prix de revient est plus élevé que le prix du pétrole."

output estimated at 9.5 Gl. Much of this is produced from ethylene, the notable exception being beverage alcohol. There is no free market in alcohol trade, as there are tariff and non-tariff regulations everywhere except Switzerland and the USA. Therefore prices are more a matter of negotiation than in molasses trade.

Other papers covered the use of molasses in the producing countries, notably the papers by Paturau(11), and that on livestock feeding on molasses written by Preston(27). Brown(28), estimated the production cost of molasses based ethanol in a 10 kt/a (at 95%) distillery to cost US\$200/t + the molasses cost (end 1976 prices). Other articles written by people from Vogelbusch GmbH(29) and the Finnish State Alcohol Monopoly(30) gave the European state of the art in ethanolic fermentation technology.

Another meeting was organised by UNIDO in March 1979, the "Workshop on fermentation for use as fuel and chemical feedstock for developing countries"(31). The review paper from this workshop combines the statistics given in the different papers, including those for cane yields (33.5-90 t/ha), investment costs (US\$5-6 M for 30, 50 or 60 kl/d), manufacturing costs (3 out of 4 values close to US\$230/kl), and energy balances.

There have been many other conferences on fermentation ethanol production, the largest recent one being the 4th International Symposium of Alcohol Fuels Technology, Guarujá, São Paulo, Brasil, 5-8 October 1980. No attempt will be made here to list all the papers given at this and other conferences, instead certain articles of interest according to the criteria mentioned at the beginning of this survey will be discussed.

### 2.1.1. Local experiences—implications for technology assessment.

To show there is nothing new in the world of producing ethanol from molasses, here is a description of the history of anhydrous alcohol production in Jamaica, taken from Sangster(32) :

In 1952, a distillation plant for production of anhydrous alcohol was built at Caymanas Sugar Factory, outside Kingston, Jamaica. This was done by the Sugar Manufacturers Association, stimulated by very low molasses prices and a poor overseas rum market. The alcohol so produced could be marketed duty free at a price equal to the then duty paid gasoline price. Government's prior approval for use of the alcohol as a motor vehicle fuel on a duty free basis was obtained. The plant, supplied by APV of England, was completed, with a capacity of 300 gallons per hour of anhydrous alcohol (by benzene azeotropic distillation of 96° alcohol from neighbouring distilleries.) unfortunately, by the time production commenced, government had changed its position on the decision to allow the alcohol to be sold duty free. This about-face was probably a result of both oil company pressures and a realisation of the revenue loss from the duty on gasoline replaced by duty free alcohol. Several hundred thousand gallons of anhydrous alcohol already produced were permitted to be added to gasoline for use on sugar estates only (10% on gasoline). Government purchased the anhydrous alcohol plant at cost less 5% depreciation, and it was closed down. Today over 25 years later it still stands much as it was left, apart from the theft of most small non-ferrous fittings. The design, however, is now so outmoded (e.g. channel caps instead of bubble caps on the columns), that it is unlikely to have much more than scrap value. Alternatively, it could be kept as an Ozymandias-like monument to the shortsightedness of some politicians.

One wonders how many of the distilleries being erected today might suffer the same fortune. Doubts have been expressed about the new alcohol distilleries in Kenya(33). The Kenyan government has taken a majority share in two molasses alcohol plants under construction in 1981 with a combined capacity of 120 kl/d. This would provide alcohol for blending with gasoline and for the plastics and beverage industries. According to a simple calculation of added foreign exchange earnings from exporting refinery products locally substituted by ethanol, the foreign exchange savings would be about



US\$50 M. Yet there are hidden costs, most notably as there is no good quality uncultivated land in Kenya, so land for sugarcane is taken out of crop production, leading to food imports. The two distilleries using molasses are being built far away from their supplying sugar factories, thus paying transport costs and not being able to take advantage of sugar factory steam and electricity. Neither these costs, nor the transport of the ethanol from western Kenya to Nairobi for blending, have been considered in the original cost-benefit analysis. The following detailed criticism of one of the projects, the Kenya Chemical and Food Project (KCFP) is taken from O'Keefe and Shakow(33) :

The KCFP, initially costed at some US \$55 million, was to produce ethanol, citric acid, baker's yeast and vinegar. Ethanol dominated the output. It was located at Kisumu, some 60 kilometres from the nearest source of bagasse and molasses. Costs have now risen to US \$138 million. In order to obtain further capital, the complex was expanded to incorporate a sulphuric acid and an oxygen plant. To complete even the ethanol production system, a further US \$23 million is required. Final costs are likely to exceed US \$230 million. Independent estimates suggest that costs should not have exceeded US \$30 million. At these cost levels, Kenya's ethanol production units are significantly more expensive than the American, Brazilian or Zimbabwean complexes.

The local market for the products, other than ethanol is small. For example, in 1979, Kenya imported 58 tons of vinegar although the KCFP has the capacity to produce 2000 tons. The situation is similar for citric acid and baker's yeast. Given the high cost of production, it is doubtful if an export market will be found. The KCFP assessment further assumes that, despite the distance from the producers, molasses would be obtained at US \$20 per ton at the factory gate. At the present moment, molasses brings US \$110 per ton on the world market. . . .

Since the ex-factory cost of ethanol is a function of the cost of the plant and the cost of the raw material—as a technologically intensive process little labour is used—and both these costs are high, ethanol will cost US \$1.90 per liter which is more than double the pump price for gasoline. The Kenyan government will have to forego tax revenue in order to hold petroleum prices to a non-inflationary level. But if the project were abandoned, the

Kenyan government, as the majority equity holder, would lose considerable capital. Poor project appraisal, based on a misunderstanding of ethanol economics, poor planning and, most importantly, poor decision-making have produced a situation wherein the chemical complex continued to expand in order to come closer to profitability. But given market conditions, profitability was simultaneously receding.

What an economist would call "externalities" and others the politics of decision-making can often dominate a project and determine its outcome. A paper that explicitly considers this in the Puerto Rican context has been presented by Thorne(34). Compare this with a paper called "Brazil's energy alternatives"(35) in which statements such as, "The only problem concerning large-scale sugar cane plantation is the need for a migratory flux of workers to the areas to be tilled;", are possible. This reduces the problems of exploitation of migratory and plantation labour to a simple consideration of whether enough such workers can be found to keep the plant running.

Other examples of such externalities are the reality of molasses exporting from Tanzania as explained by Mungai(36). Tanzania has entered into a seven year contract to supply 140 kt of molasses, but from 1974 to 1978 it had exported an average of only 13 kt/a because of transport problems. Furthermore, the transport costs reduce the molasses price from US\$38/t at Dar es Salaam to US\$16 at the sugar factory. So these transport difficulties and costs might make ethanol production at the factory more favourable than it would be in the typical "free market" ethanol distillery costings which appear in the literature. In Brazil, Pelin(37) has shown that the development of the Proalcool programme to produce fuel alcohol from sugarcane and molasses in the state of São Paulo has taken land out of domestic crop production to the extent of 51.0% of the new cane land (9.0% were taken from export crop production, 40% out of pasture). So even

in countries with large areas of land not under crops, local market pressures created by a fuel alcohol programme can take land out of food cultivation.

### **2.1.2 Alternative technologies for ethanol production.**

There are many references to the production of ethanol on medium and large scales(38,39,40,41,42,43,44,45,46 and many others). Such large distilleries are typified by Archer-Daniels-Midland Company's three distilleries in Decatur and Peoria, Illinois and Cedar Rapids, Iowa, which have a combined capacity of 150 Mgal/a (570 Ml/a)(47). According to the theory of economies of scale, such large factories should be able to produce ethanol at a price that could undercut any smaller producers. Yet, even in the United States, there are many small-scale alcohol distilleries. Canadian Renewable Energy News(47) listed 17 of them, with capacities ranging from 1.1 Ml/a to 9.5 Ml/a. The same article reported on the difficulties of the larger plants arising from high maize prices and reduced petrol consumption, so that some large plants were producing at only one third capacity. At the same time entrepreneurs with small plants were taking advantage of waste products, locations close to the consumer. One example of the adaptation to circumstances that is possible in small, less mechanised, plants was when Northwest Pacific Energy Co. ran out of spoilt grain and had to use jelly beans and candy bars for a short time.

Sklar carried out a study of five on-farm ethanol units in the United States(48). These produced from 57 l/d (~17 kl/a) to 1.5 Ml/a. All used maize as the feedstock, and, therefore, benefited from sales of distillers spent grain, as well as local tax conces-



sions. Many were self built, one by a moonshiner. The 1.5 Ml/a plant produced ethanol at US\$0.32/l and provided a 35% return on investment after taxes. This plant has recently had a molecular sieve drying column added to produce anhydrous ethanol.

The Solar Energy Research Institute has produced a guide to small-scale ethanol production, called "Fuel from Farms"(49). In this they outline a method for for plant scale choice and feasibility calculations based on local conditions, with examples. This is almost the small-scale equivalent of "A manual on ethanol & gasohol production in Louisiana"(50). On a slightly larger scale, a group at the University of Alabama and Dixie Steel and Supply Company have designed and built (but not at the time commercially tested) a prototype "community-sized fuel alcohol production unit"(51). They defined community-sized to be in the range 0.6-7.6 Ml/a, and the prototype has a capacity of 2.3 kl/day. This was based on grain feedstock, and used a gas fired boiler for steam generation. Batch fermentation is used, and separate analysing and rectifying columns.

Of more interest to tropical developing countries is the micro-distillery designed by the Instituto de Pesquisas Tecnológicas do Estado de São Paulo (IPT). This project was undertaken to enable small rural communities to become self-sufficient in liquid fuels. This prototype was constructed in Piracicaba(52,53,54,55,13,56).

In 1977, the project began with the fundamental design objective to reduce to the minimum the investment needed to produce local fuel, through using simple equipment, unlike that in conventional alcohol distilleries. The reference unit was taken to be a farm of about 250 ha, consuming 25 kl of diesel annually (a medium tractor

for 6000 hr/a and a 5 t truck covering 60 000 km/a). Taking the heat content of alcohol as 60% of diesel, they calculated that this would require 40 kl/a, say 50 kl/a allowing for some alcohol fueled electricity generation.

To reduce costs, they used brickwork tanks for fermentation, and the storage tanks for cane juice, "beer", vinasse and cooling water. The sloping grate furnace was built of refractory bricks, in which was mounted a locally constructed vertical fire tube boiler.+ The still and column were built out of wood. The column was filled with bamboo Raschig rings, supported on wooden vapour distribution perforated plates. Similarly, the condenser and cooler were of wood construction, containing copper coils (for good heat transfer). The cooling water flowed outside the coil in the cooler, and inside the coil in the condenser. The number of pumps was reduced to a minimum by taking advantage of the site to allow gravity feed. At the Escola Superior de Agricultura de Queiroz in Piracicaba, three PVC pumps were used to pump the juice to the fermentation tanks, to pump the "beer" to the distillation column and to circulate cooling water. If a pump was needed for the vinasse, it would have had to be of stainless steel or phosphor bronze, to resist the temperature and corrosivity of the vinasse. Most of the tubing was of PVC, for cheapness and corrosion resistance. Only the tubes subject to high temperatures were of metal, mild steel for cooling water and steam, cast iron for the hot vinasse, and copper in the heat exchangers. The cold vinasse was carried in glass fibre reinforced PVC pipes. The alcohol produced was stored in a ferro-cement tank, constructed on site, and

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+ In the construction manual a horizontal fire tube design is specified(13).

lined with a suitable alcohol-resistant paint or resin. A small single roll mill was used to crush one tonne of cane per hour, fed manually. This was similar to the mills used in Indian khandsari plants. It produced about 500 l juice per hour.

This equipment is illustrated in appendix 1 by photographs and drawings taken from the construction and operation manual produced by IPT. This is included for the benefit of readers outside Brasil who might not have access to copies of this manual, since only 1000 copies were produced in the June 1980 edition.

In use, the juice from the cane mill was pumped to the juice storage tank and from there to the fermentation tanks on top of the yeast-containing slops from a previous fermentation, and allowed to ferment for 24 hours. After fermentation was complete, the tanks were allowed to settle for one hour, then the "beer" was pumped to its storage tank and from there to the still. Sulphuric acid was added to the slops to reduce the pH to 3 and the mixture was agitated for two hours. As yeasts can tolerate more acid conditions than bacteria, this reduces bacterial contamination. The still was operated in batches, discharging the vinasse after each distillation. The vinasse was not to be treated in any way but spread on the fields as a fertilizer.

The pilot plant proved capable of producing 51 kl ethanol on one shift operation for six days a week over 29 weeks. It produced 45 l of ethanol at 90%. This yield was lower than that at the larger sugarcane ethanol distilleries, mainly as a result of lower sugar extraction from the cane in a single mill without imbibition water. The fermentative yield was 75% of theoretical, which was better than

the total fermentative and distillation efficiency of 70% achieved in the Mauritian rum distilleries. Assuming that the distillation to 90% ethanol lost only a negligibly small proportion of the ethanol, this means that the mill only extracted sugar equivalent to 8% of the weight of cane crushed. Because of this the team at IPT were studying the extraction of sugar in a screw press using cold water at 40 atmospheres pressure.

Villen(53,52) gives capital and operating costs for this plant, as tested and expanded to produce 100 kl/a on two shifts and 150 kl/a on three shifts.† These costings are reproduced in figure 2.13. Note that these costings are different to those given for the same plant in the Centre for Industrial Development's "Inventory of adapted technologies for ACP countries"(57). This is a compilation of case studies, taken from many sources without acknowledgement (nor any indication of where an interested reader might find more information on the technologies), with costings recalculated by anonymous economists according to a set of unit costs in unspecified ACP countries. In the profile on a "Microplant for ethyl alcohol production", such an anonymous economist has calculated the production cost of alcohol to be US\$0.73/l at a 5% discount rate, US\$0.76/l at 10% and US\$0.85/l at 15%. However, Villen calculated the ethanol price to be US\$0.42/l for a one-shift, 50 kl/a distillery and only US\$0.34/l for a three-shift, 150 kl/a distillery. Why the difference?

On looking closer at the calculations of this anonymous economist, one finds that a manager and 12 workers are required to produce

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† These are for six days per week working. The quantities produced when working seven days per week on 1, 2, and three shifts are 64.9 kl/a, 129.9 kl/a and 194.9 kl/a respectively.

Figure 2.13 Costings of the IPT microdistillery.

ESCALA DE PRODUÇÃO	1 TURNO 64 900 L/ANO	2 TURNOS 129 920 L/ANO	3 TURNOS 194 880 L/ANO
ITEM DO CUSTO	CUSTO (CR\$)	CUSTO (CR\$)	CUSTO (CR\$)
Cana-de-açúcar a Cr\$ 468,15/t	675.072,30	1.351.549,05	2.027.557,65
Mão de obra + encargos (S.M. = Cr\$ 4.149,60)	151.616,60	312.717,44	502.270,72
Energia elétrica e demais in- sumos	37.245,36	74.352,29	111.440,73
Manutenção (2% a.a.)	30.000,00	30.000,00	30.000,00
Seguros (1% a.a.)	15.000,00	15.000,00	15.000,00
Retorno de capital (10 anos - 12% a.a.)	265.350,00	265.350,00	265.350,00
<b>TOTAL DOS CUSTOS</b>	<b>1.174.283,30</b>	<b>2.048.968,78</b>	<b>2.951.619,10</b>
<b>CONTRIBUIÇÃO POR LITRO</b>	<b>18,09</b>	<b>15,77</b>	<b>15,15</b>

Table III						
Item	Annual Production					
	50,000 L		100,000 L		150,000 L	
	US\$	%	US\$	%	US\$	%
Raw material	0,2540	60,97	0,2540	70,54	0,2540	74,42
Labor	0,0497	11,93	0,0497	13,80	0,0497	14,56
Investment cost	0,1014	24,34	0,0507	14,08	0,0338	9,90
Maintenance	0,0115	2,76	0,0057	1,56	0,0038	1,12
<b>Total Cost</b>	<b>0,4166</b>	<b>100,00</b>	<b>0,3601</b>	<b>100,00</b>	<b>0,3413</b>	<b>100,00</b>

Table II	
Item	Investment
Cane crusher	US\$ 3,822.99
Distillation column	US\$ 4,778.74
Boiler and furnace	US\$ 8,410.59
Building, etc.	US\$ 6,403.52
Vats, piping, pumps, etc.	US\$ 1,911.50
Installations	US\$ 1,911.50
Reinforced cement-mortar tank	US\$ 1,433.62
<b>Total</b>	<b>US\$ 28,672.46</b>

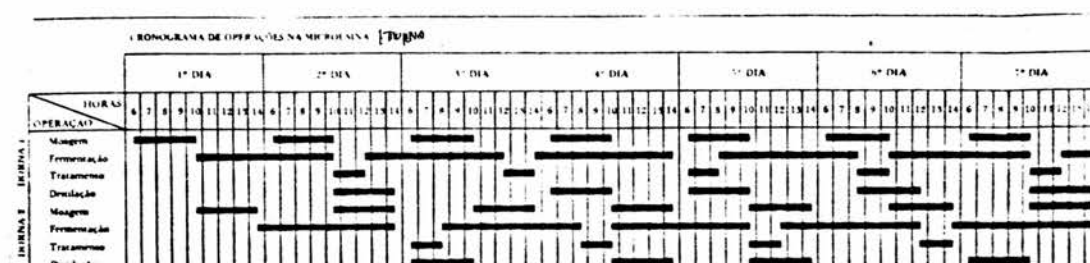
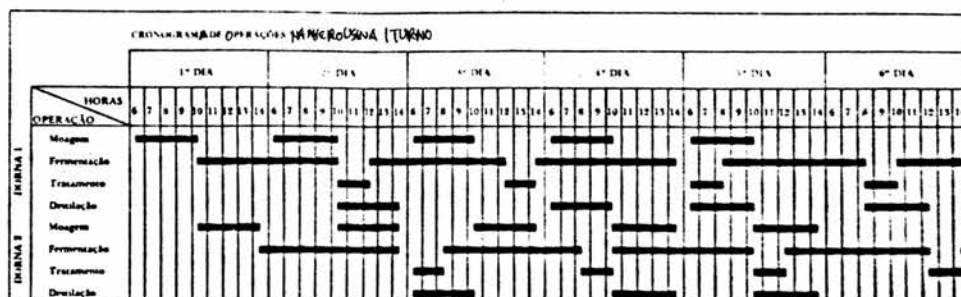
Source: Villen(52,53).

50 kl/a. Yet in the Brazilian references, only three workers are required. They provide time charts (see figure 2.14) to show how the distillery can be operated on a one shift basis so that it never needs more than three workers.

It appears that a technologically incompetent economist has read Villen's paper of the same title as his study very quickly, seen a reference to the plant requiring three employees per shift and assumed that as a distillery "must" be run continuously, there would be four shifts. He failed to understand the design of the microdistillery, as a minimal capital cost plant that could be operated on a one shift basis to produce 50 kl/a ethanol and later expanded to a

Figure 2.14 Time chart of operations in the microdistillery, on 6 and 7 days per week bases.

CRONOGRAMA DE OPERAÇÕES NA MICROUSINA



Source: Manual de Construção e Operação de uma Microusina de Alcool Etílico(13).

plant capable of producing 150 kl/a on three shift operation, or 194.9 kl/a when run continuously for 29 weeks, seven days per week.

His other assumptions seem more reasonable, as cane is cheaper in Brasil than in many ACP countries, and Villen's costing assumes that in a remote area cane can be obtained more cheaply than at a sugar mill (as indeed is the case at Indian gur and khandsari mills). The building costs, however, seem high, and probably imply too high a degree of environmental protection for a fairly rugged plant. Overall, this anonymous economist has succeeded in reducing the value of these profiles to the level of the "profiles" found in certain Indian publications, such as in the "Techno-Economic Mission to Mauritius"(58).

### 2.1.3 Economics of fuel ethanol production.

As has already been mentioned, these are not often the principal considerations that cause decisions to be taken on whether or not fuel alcohol distilleries should be established in a particular country. For this reason, and because many of the economic factors are specific to a location, the literature on this field will not be extensively discussed here.

Undoubtedly the most comprehensive economic assessment of ethanol production under United States conditions was produced by the Mitre Corporation(59). This reviewed 28 processes which had appeared in 14 ethanol-from-biomass studies during 1976-8, in the context of a common economic analytical framework: their life cycle cost model. The different processes were based on maize, sugarcane, molasses, wheat straw, wood, and algae. Among them is the Battelle study already mentioned. Another US study that concentrates more on sugarcane is the "Manual on ethanol & gasohol production in Louisiana"(50).

Neither of these studies consider European technologies designed to reduce energy consumption(60,61,62,63), or for continuous fermentation(64,43,65,66,67). The effects of such technologies on the potential for producing biomass ethanol in the United Kingdom (not from sugarcane), as outlined in a paper by Emery and Kent(68). A fuller report on the conversion of UK biomass to ethanol and other liquid fuels will shortly be available from the Energy Technology Support Unit at Harwell.

More relevant to developing countries is the article by Paturau which directly addresses the question, "Is ethanol the fuel of the



future for sugar cane producing territories of the Third World?"(69). In this article is considered the energy balance for the sugar factory with annexed distillery, the production costs from cane juice and molasses, and the merits of ethanol as a fuel.

Also relevant to developing countries is the Brazilian experience, although prices are determined by government policy which guarantee a return on ethanol distilleries, and which maintain a low cane price compared to that of sugar. Such costings can be found in Borges(41), and "The Brazilian alcohol program and its objectives"(40), among others.

Among costings from other sugar producing countries are those by Bejraputra(39) for Thailand, and McCann and Prince(70) and Kelly(44) for Australia. This latter suffers from the tendency to take recent changes such as increased agricultural mechanisation as given, as illustrated by the following quotation:

Agricultural machinery is generally not distinguished for the standard of maintenance achieved, perhaps more so when small scale units are employed. The most costly and physically largest mechanical unit employed on the sugar cane plantation is the present day chopper type harvester. At present practically every stick of cane in Queensland is mechanically harvested, but a study of statistical records indicates that these very costly machines are being used to only about 13% of their potential capacity.

It is rare to find an ox-cart which is broken down for 87% of the year. So his very own evidence contradicts his assertion that small scale units are worse maintained than large. The ideological assumptions override logic here and elsewhere in his paper. Finally, many feasibility studies have been carried out around the world for the establishment of power alcohol distilleries based on molasses or sugarcane. These are normally confidential to the government con-

cerned. However, one study has been published as part of the OAS study on by-product use in Jamaica(8). This part of the study was carried out by a Brazilian team. They established that the market for ethanol for blending with petrol was much greater than the amount exceeded molasses availability and so scaled their study on the molasses supply, with one exception. For they claimed that the smallest distillery available from the manufacturers had a capacity of 12 kgal/day (55 kl/d), i.e. 3.9 Mgal/a (18 Ml/a). This may have been true in Brasil, but as has been shown above there are smaller distilleries produced in the USA. For their chosen distillery they showed that ethanol production would be uneconomic at the then prevalent petrol and molasses prices.

#### **2.4. Other molasses uses.**

The predominant use of molasses worldwide is in animal feeding. Some references on this subject can be found in the section of this review that deals with animal feed from sugarcane by-products, others in the bibliography.

Bakers yeast production is dealt with in depth in the chapter on the Mauritian yeast factory, Yeast Producers (Mtius) Ltd. References on this subject will be found in that chapter. Also note that a profile of bakers yeast production at 500 kg/24 hours has been produced by the Centre for International Development(71).

References to other products from molasses may be found in the bibliography.

### **3. Uses of bagasse.**

There have been few general reviews of the utilization of

bagasse to the depth of Paturau's book, since it was published. A short article has appeared in the 3rd edition of the Kirk-Othmer Encyclopedia of Chemical Technology(72), and Li Sui Fong has written a brief review of new uses for bagasse(73). Paturau's articles on the utilization of both molasses and bagasse have already been mentioned.

Some general reports have been written on the potential uses of bagasse in individual countries, most of them confidential such as a report on the use of bagasse in Mauritius prepared by J. Olivier, who has summarised his ideas on the range of possibilities in a pamphlet(74). Other studies have been carried out by UNIDO consultants, such as one on Fiji, by Travnicø(75).

### 3.1. Availability of bagasse.

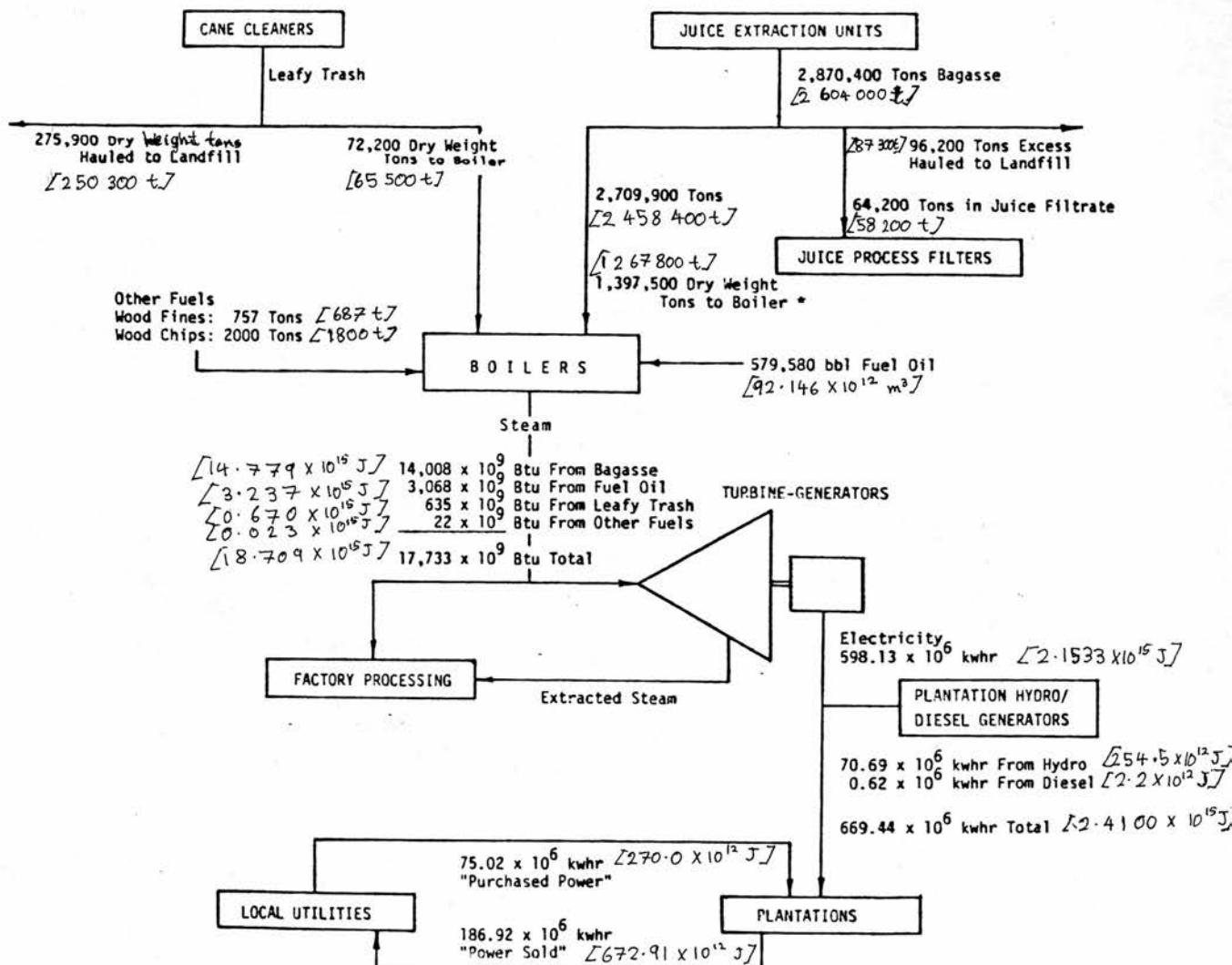
This subject is intimately tied to the energy requirements of the sugar factory, for the more efficiently it uses its energy, the more surplus bagasse is available for conversion to electricity or fibre-based products. It is in the countries which are already making use of electricity generated from bagasse that produce the most detailed studies on this. Notable among them is the "Energy Inventory for Hawaiian Sugar Factories—1978"(76), and papers presented at the University of Mauritius Seminar on Energy and Energy Conference, including d'Espaignet(77). The summary of the fuels used, steam energy produced and electricity produced, sold and consumed in Hawaii is shown in figure 2.15.

D'Espaignet described the energy balances of the present

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⊕ Available only from, or with the permission of, the Fiji government.

Figure 2.15 Hawaiian raw sugar factories—Summary of fuels used, steam energy produced, and electricity produced, sold, purchased and consumed.—1978



\* Fiber and unextracted sugar.

Source: Energy inventory for Hawaiian sugar factories—1978(76)

Mauritian sugar factories, and possible improvements under various conditions. Other articles, discussing potential improvements to the steam cycle and bagasse drying in order to make more surplus bagasse available, by Paturau have already been mentioned in this survey.

Experiments on bagasse driers that led to the installation of

such a drier in a Dedini boiler in Alagoas, Brasil have been reported by Maranhão(78). He reported an increase of steam production of 16% or an increase in surplus bagasse production by 13% from the installed bagasse driers.

When surplus bagasse is not sufficient, another fuel has to be substituted for the bagasse in the mill. The procedures for calculating the replacement values are well established (see Paturau's book, and articles by Atchison), but a recent article concentrates on the difference between the fuel values of pith and whole bagasse(79). This is important where bagasse is to be used for paper or fibreboard production, and the moist-separated pith is returned to the sugar factory for use as a fuel. The article details the experiences of mills in Venezuela, South Africa, Peru and Taiwan. Overall, the steam generated using pith can be 10-15% less than when burning whole bagasse (undried in both cases).

### **3.2. Bagasse storage.**

Walter has written an article(80) touching on some of the aspects of his PhD dissertation on the storage of bagasse. In it he lists the microorganisms that grow on decaying bagasse, the relative ineffectiveness of biological preservation systems, and of preservation with boric acid. His tests showed that organic sulphur compounds were effective preservatives of bulk stored bagasse at 0.1-0.2%.

Descriptions of the bagasse storage system at a working pulp mill in Taiwan have been given in an article by Wang(81). They use a bulk, bio-liquor system for storage. While the systems used in Cuba have been discussed by Lois et al(82).

### 3.3. Electricity from bagasse

The articles by Paturau and D'Espaignet, already mentioned, consider the production of electricity from bagasse. <sup>In 1978,</sup> 31% of the electricity generated on Hawaii, Kauai and Maui came from bagasse(76).

In larger countries, less intensively covered by an electrical grid, fewer factories generate electricity for sale outside the factory. Rao described the situation in India(83).

In other countries a suitable grid has existed, but a lack of interest by either the sugar factories or the electricity supply authorities has hindered attempts to export power from the factories. One attempt to overcome such a situation was the negotiation of an electricity interconnection agreement in Queensland(84).

These agreements have to be updated, or changes in the opposite sense occur. Arzola(85) explains how interconnection agreements established in Puerto Rico in the 1950s whereby factories bought electricity from the grid at a reduced rate, and were paid for surpluses at the cost of the most efficient Puerto Rican generating plant, were maintained into the 1970s. Under the changing economic conditions, the factories chose to save on fuel oil by buying more subsidised electricity from the grid, and exporting very little power.

Other articles on electricity generation can be found by consulting the bibliography, not all as good as the articles mentioned here. For example, Rodriguez Torres and Horta(86) outline a way to convert a Puerto Rican sugar mill from sugar production to power production by converting all the sugar to ethanol and then burning this

in a gas turbine, and using the bagasse to provide electrical energy. This is energetic nonsense. For most distilleries have a net negative energy balance, requiring more energy to distil the ethanol than is in the ethanol produced. When the distillation is fueled by bagasse, this is a reasonable way of converting a solid, bulky, energy source and sugars to a high value liquid fuel for transportation. Yet Rodriguez Torres proposes to burn this ethanol to provide electrical energy when the bagasse (and molasses) can be burned directly to produce steam for electricity generation.

### **3.4. Bagasse board.**

Particleboard production from bagasse is discussed in detail in the chapter which analyses the failure of the Mauritian particleboard plant. Only a few references of interest will be mentioned here.

A historical review of the composition panelboard industry, stressing the use of non-wood fibres has been written by Atchison and Collins(87). Figure 2.16 shows their list of bagasse fibreboard and particleboard plants that had been built up to 1976, and figure 2.17 shows how the consumption of particleboard is overtaking that of plywood worldwide.

Another, earlier review on the subject was a meeting organised by UNIDO, "Production of panels from agricultural residues"(88). This considered all agricultural residues, and was primarily concerned with production in developing countries, as was a later FAO organised "World Consultation on Woodbased Panels"(89,90,91,92,93,94).

As a result of this conference, a number of particleboard equip-

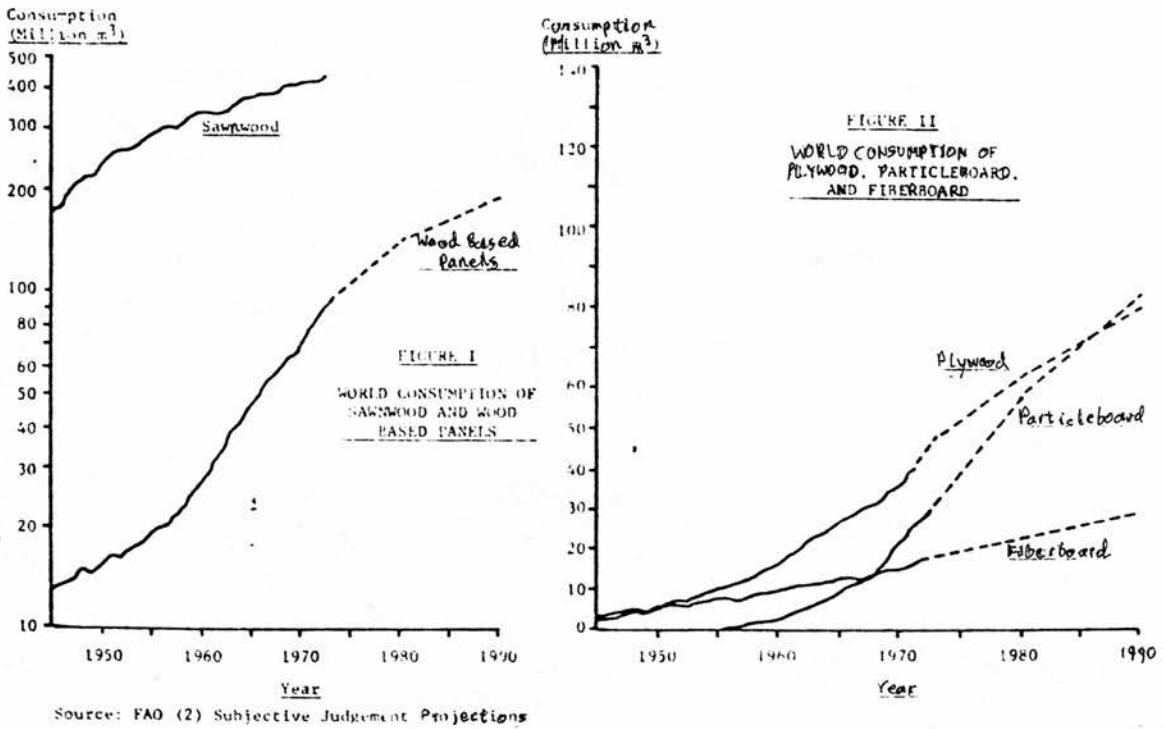


Figure 2.16 Bagasse particleboard and fibreboard plants known to Atchison(87) in 1976

<u>Name of Plant</u>	<u>Location</u>	<u>Rated Capacity and Product (MT/Day)</u>	<u>Year of Start-up</u>
1. Celotex Corporation	Louisiana U.S.A.	600 Insulation Board	1920
2. Taiwan Chienyeh Corp. (Formerly owned by Taiwan Sugar Corp.)	Taiwan	60 Insulation and S-2-S Hardboard	1956
3. Compania Primadera	Cuba	40 Insulation and S-2-S Hardboard	1959
4. Henetex	Cuba	10 Insulation Board	N.A.
5. Crescent Sugar Mills	Pakistan	60 Insulation and S-2-S Hardboard	1972
6. Durite Corporation	Puerto Rico	200 S-2-S Hardboard	1976

<u>Name of Plant</u>	<u>Location</u>	<u>Capacity (MT/Day)</u>	<u>Start-up Time</u>
1. Cuban Bagasse Products (PRO-CUBA)	Cuba	50	1958
2. Fibrelite Corp. (Originally National Bagasse Board, Ltd.) (Closed)	Louisiana	40	1961
3. Kaohsiung Bagasse Particle Board Factory	Taiwan	60	1961
4. Ryunyu Chemical Ind. (Closed)	Okinawa	60	1961
5. Kom-ombo Bagasse Particleboard Plant	Egypt	40	1964
6. Tablopan de Venezuela	Venezuela	70	1964
7. Les Sucreries de Bourbon	Reunion	42	1966
8. Standard Building Products, Ltd. (Closed temporarily 1975)	Jamaica	100	1967
9. La Salud	Cuba	40	N.A.
10. Hulsakane, Ltd. (Closed temporarily 1975)	South Africa	120 Expandable to 180	1972
11. Universal Board, Ltd.	Mauritius	15	1972
12. Crescent Sugar Mills	Pakistan	30	1972
13. Trinidad Bagasse Products, Ltd.	Trinidad	40	1973
14. Ultrabond (Pty) (Bison-Mende Process)	South Africa	100	1975

Figure 2.17 Consumption of boards, worldwide.



Source: Atchison and Collins(87)

ment manufacturers were asked to provide case studies of small scale particleboard plants(95,96). A number of companies now offer "small scale" plants for particleboard(97) and fibreboard(98), however, these plants are often still too large for small Third World markets.

Marenzi(90) studied the operation of two small-scale fibreboard plants, one in Madagascar of 10 t/d capacity and one in Kenya of 24 t/d. Another African plant was described in the Centre for Industrial Development profile(99). This produced 24 t/day hardboard, medium density board and insulation board. These three small fibreboard plants used wood. De Wilde studied much smaller strawboard plants in Sri Lanka(100,101), which suffered from political selection

of an untrained work force and management. Mars(102) studied in some detail particleboard production in India in order to assess the feasibility of producing particleboard from groundnut husks. figure 2.18 shows the plywood and particleboard end uses in India.

Figure 2.18 India: Plywood and particle board end uses: 1964-5.

		Plywood		Particle Board		
				Flat pressed	Extruded	
	a	b	c	d	e	f
		%	cu. m.	%	%	cu. m.
1	<u>Furniture</u>	3.0	2,900	39.5	28.0	...
2	Movable	...	...	28.5	21.8	...
3	Built-in	...	...	13.0	7.0	...
4	<u>Construction</u>	28.5	27,590	44.0	69.0	...
5	Doors	...	...	5.0	57.0	...
6	Flooring	...	...	8.0	...	...
7	Floor underlayment	...	...	...	...	...
8	Ceilings	...	...	7.5	...	...
9	Roof Underlayment	...	...	...	...	...
10	Walls partition	...	...	26.5	12.0	...
11	Concrete Formwork	...	...	...	...	...
12	<u>Transport</u>	17.0	16,460	15	-	-
13	<u>Other</u>	51.5	49,850	1.5	3	...
14	<u>Total</u>	100.0	96,800	100.0	100.0	(9,440) <sup>(1)</sup>

Source: Mars(102).

In her discussion of the panel markets in India she explained that the plywood used in furniture was mainly 15 mm to 19 mm, used in better quality furniture. This is quite unlike the Mauritian usage of thin plywood for cheap furniture.

Brief mention should be made of other board products that have been or might be made from bagasse. These are cement-bonded board(93,103), medium density fibreboard (MDF)(104), and oriented boards(105,106,107).

One of the most significant costs in particleboard production is

the cost of synthetic resin. Research done on trying to find natural products to substitute for this (as lignin does in fibreboard) has been reviewed by Kulvik(108).

Last but not least should be mentioned the most important article on particleboard production that the author has read. It is "Possibilities and problems regarding production of particleboard in the developing countries" by Bassili(109). This is the only article known to the author which directly concerns itself with the marketing / user education problems discussed in the chapter of the thesis on the Mauritian particleboard factory. These problems are well known in the industry, but are rarely mentioned in the literature.

### **3.5. Pulp and paper production from bagasse**

A case study of a proposed paper mill in Jamaica(8), is critically compared with a study in Indian small scale paper mills(110), and articles on bagasse-based Indian mini-mills(111,112,113), in a later chapter in this thesis. This literature survey of bagasse pulp and paper will, therefore, be limited to mentioning the reviews and principal articles on the technology of pulp and paper production from bagasse.

There has been an extensive bibliography prepared on the pulping of bagasse, by Loudon(114), with 132 references, with abstracts of each. Other references are available from the Finnish Pulp and Paper Research Institute(115).

After Paturau's book was published, UNIDO held an "Expert group meeting on pulp and paper", in which several papers were devoted to the production of bagasse newsprint(116,117,118).

Several papers have been published on the results of particular working mills. Wang(119) described the decision-making leading to the establishment of a 300 t/d bagasse pulp mill (then the world's biggest), special features of the project and improvements made during test operation. Several stages of feasibility studies were carried out. The first was by local consultants (China Technical Consultants), the second by a Canadian company (Stadler Hurler International Ltd.) which agreed with the local study and quantified some of the factors (e.g. market size) and investigated some extra factors (water quality and effluent disposal). The third stage was the setting up of a Construction Office for the project, advised by four experts. They had to prepare the tender specifications, evaluate the bids, advise on construction and civil works, on the installation and test run, on the bagasse storage and transportation system and plan the personnel training programme. They studied the process to be used, the plant size and the site before preparing the tender specification.

The sulphate process was chosen over the soda, sulphite, caustic soda-chlorine (Celdecor) and mechano-chemical processes as bleached pulp for export was to be produced, and the process produced a relatively strong pulp of good flexibility while permitting chemical recovery by a well-developed process.

The plant size was established from the bagasse supply available from sugar mills at economical transportation distances, as there appeared to be no severe market limitations for such pulp in the region. The factory site was chosen taking into account the raw material supply and storage, chemicals supply, water quality and supply, fuels and power, transportation facilities, labour resources,

climate, and effluent pollution.

On this basis they invited tenders for a turn-key plant, erected by the Taiwan Sugar Corporation under supervision. The specification included conditions that 30% of the equipment, machines and materials should be manufactured in Taiwan; the supply of field engineers for erection supervision, testing, start-up and performance tests and training; that the supplier or cooperating manufacturer must have had experience in supplying relevant equipment three years before 1 July 1971; and the following:

Supplier or its cooperating engineering firm must have designed or constructed at least one complete bleached bagasse pulp plant using Alkaline Process to produce 85° GE or over bleached pulp at design capacity not lower than fifty metric tons per twenty four hour day. This plant should have met performance guarantees and should have operated at design capacity for at least one year before July 1, 1971. A notarized letter from the Chief Executive of the mentioned pulp mill is required to certify the mill's capacity, the brightness of the bleached pulp, date of initial operation and performance test runs and the name of the designing (sic) and or construction (sic) of the plant.

With such conditions it is perhaps not surprising that the tender was opened and retendered three times from August 1970 to June 1973, when it was finally awarded to Ishikawajima-Harima Heavy Industries Co. Ltd., cooperating with Parsons Whitmore Co.

The plant had a mechanised bagasse feeding system for unloading bales which arrived by train from sugar factories, an improved Ritter bulk storage system in which a biological liquor is prepared containing acid-producing bacteria and pumped over the bagasse in a yard, and a wastewater treatment plant including neutralisation, sedimentation and activated sludge steps.

As some parts of the design did not work in practical operation,

they made several improvements. Such changes were made to the bagasse pusher, the dump pit, the bale breaker and the depither which had had its suspension and lubrication system completely modified before installation. Nevertheless, it suffered from vibration, lubrication and centre alignment problems, and its capacity was below design level. Faced with this the engineers of the Taiwan Sugar Corporation replaced the pin bagasse feeder to the depither by a screw feeder so that they could ensure an even feed flow, enabling the depither to run at maximum load condition all the time.

If more projects were started, studied and run like this one, there would be less failed industries in developing countries.

Other bagasse pulp and paper mills reported in the literature include the Mandya National Paper Mills Ltd., Mysore, India(120), the Orizaba mill in Mexico(121), the Stanger Pulp and Paper mill in South Africa(122), the Edfu pulp mill in Egypt(123),\* and a new pulp and paper mill in Cuba, Project Cuba-9(124). The 35 t/d Indian mill had difficulties, for two and a half years after start-up, in power and bagasse supplies. The bagasse was moist depithed at the sugar factory, further depithed in a Hydrapulper at the pulp mill, and continuously digested with caustic soda in a Black Clawson Pandia digester. The pulp was then bleached by a three-stage process. They succeeded in making printing paper from 100% bagasse pulp, although the plant was designed to use 20% long fibred pulp. Nevertheless they preferred to use only 80% bagasse for the flexibility it allowed and the limitations bagasse draining puts on a paper machine with a normal length fourdrinier section. Note that this is an Indian mini-

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\* Only available from, or with the permission of, the Egyptian government.



mill, below the quoted "minimum economic capacities".

The Cuban plant will be a pilot plant for producing newsprint and dissolving pulp. This has been designed by ICIDCA. The Mexican plant is a 60 kt/a expansion to Kimberley-Clark's plant there, using a soda base pulping line and chemical recovery incorporating a fluidised bed liquor burning system which can burn 35% solids liquor, greatly minimising the problems of chemical recovery in soda process plants.

The Egyptian mill was built in 1965 with a large chemical recovery plant to allow an early doubling of capacity. The costs of running this recovery furnace at 42% of design capacity and paying financial charges on an expensive (because of this) plant have led to it running at a loss ever since. The project seems to have been somewhat ambitious, as the Egyptian market grew slowly, and in 1969 was estimated to need an extra 32.3 kt/a extra chemical pulp by 1980—somewhat different planning to that in the Taiwanese case.

Finally, for those readers unfamiliar with the technology used in Indian mini paper mills based on agricultural wastes, appendix 2 includes diagrams and information extracted from Western(110) illustrating the processes employed. For an account of the misadventures of poorly run mini-mills in India, see a recent article in Economic and Political Weekly(125).

### **3.6. Other bagasse uses.**

Many people have tried to briquette bagasse for subsequent use as a fuel, or for easier transport to pulp mills, with varying degrees of success. One type of briquetter is produced by SPM Cor-

poration(126). It was one of these that did not work in Mauritius, although they have been successful elsewhere under different conditions. Other cheaper, small-scale briquetters are produced by Thai and Indian(127) companies. Recently machines to form highly compressed bagasse pellets have appeared. One such is the "Woodex" pelleter, which is being used in Hawaii to compress bagasse for use as a fuel at central power stations(128,129). A woodex plant of 20 kt/a capacity would cost about US\$2.83 M.

Another energy use of bagasse for which plants have been designed is the production of charcoal and/or gas by pyrolysis. Traditional types use molasses to bind the charcoal briquettes, some newer processes produce gas by pyrolysis and limited combustion of bagasse in suspension, e.g(130).

Some attempts have been made to produce biogas by anaerobic digestion of bagasse. One such plant, to a Hungarian design, was set up at the National Sugar Institute, Kanpur, India(131). This produced  $200 \text{ m}^3$  of gas with an energy content of  $5200 \text{ kcal/m}^3$  ( $21.8 \text{ MJ/m}^3$ ) from one tonne of organic matter. If we take bagasse to contain 49% water and 1.5% ash, then one tonne of wet bagasse will contain 495 kg organic matter, which could produce  $99\,000 \text{ m}^3$  biogas by this process, with an energy content of 2155 MJ. Yet burning this bagasse, with a net calorific value of  $8040 \text{ kJ/kg}$ (2p.31), this would produce 8040 MJ of energy. So in making biogas from bagasse in this process, only one quarter of the energy available by burning bagasse is present in the gas.

Other products can be obtained by hydrolysis of bagasse. Acid hydrolysis can produce furfural from the pentosans in the

bagasse(132,133,134\*), enzymatic hydrolysis might eventually produce sugars from bagasse(135,136). The Tsao process of dissolving the cellulose in bagasse, in a solvent such as concentrated sulphuric acid, and then precipitated as amorphous cellulose, which can be more easily hydrolysed(137,138). Partial hydrolysis can improve the palatability of bagasse to cattle, and can provide substrates for fungal growth(139).

Bagasse can be converted to compost without pre-treatment provided it is mixed with manure, filter mud and bacterial/fungal cultures to accelerate the decomposition(140), or sprayed with vinasse(141).

#### 4. Other by-products of sugarcane

In a number of countries, wax has been extracted from filter mud. This is done commercially in India(142,143). The only factory there at present producing wax is attached to the Ravalgaon Sugar Farm Ltd., Maharashtra. This 1200 t/d factory uses sulphitation clarification. The filter mud is sun dried and then extracted with white spirit in a batch process of successive extractions with weakening solutions of wax. The solvent is recovered from the spent filter mud by steam distillation, and the wax solution is concentrated by the same process. The crude wax is then treated with slaked lime at 120 °C, which treatment is followed by refining the wax by cold extraction in isopropanol. In India cane wax sells for about US\$8.5/kg, compared to the landed price for carnauba wax of US\$9/kg.

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\* Available only from, or with the permission of, the Trinidad government.

## 5. Animal feeding on sugarcane by-products.

As this thesis concentrates on the industrial use of sugarcane by-products, this section will be limited to indicating a few reviews of the subject.

Perhaps the fullest study of this is a thesis on the use of sugarcane by-products in cattle feeding, by Brun(144).

A shorter review appeared in the *Revue Agricole et Sucrière de l'île Maurice*(145), while a review on poultry production on sugarcane and other by-products was published by Valdivie(146).

A general introduction to the use of molasses in animal feeding has been produced by the United Molasses Co. Ltd(147).

## 6. General literature on technology transfer.

This review has concentrated upon cases of the transfer of technologies for using sugarcane by-products. These will be compared later with the Mauritian case studies, to control for specifically Mauritian factors.

A search has been made for detailed case studies of industrial technology transfer which consider explicitly the dynamics of the process. Apart from Hirschman's study(148) (already mentioned) these are few and far between. The studies in "The choice of technology in developing countries"(149) concentrate on the economic viability of different technologies at factor costs in underdeveloped countries, although Timmer(150) and Thomas(151) do consider the process by which the project proposals are produced. Wells(152) studied the choice of technology in manufacturing industry, so his paper is more relevant to this study. However, it is a cross-sectional rather than historical survey, comparing the technologies used in different factories at

the same time. He attempted to discover the reasons for investment decisions through interviews with managers, and checked their arguments against the material conditions in Indonesian industry. He suggested several explanations for this decision-making behaviour, but found that none of the economic explanations were rational to an "economic man" (except, perhaps, risk minimisation), and was forced to invoke a psychological explanation, that of an "engineering man" who pursues engineering objectives beyond the limits of economic sense. As Wells concludes, "The study has only begun to probe the complex factors that influence the manager in his choice of technologies. The simple combination of production functions and factor costs is clearly inadequate to the task."(152,p.85)

There have been a number of accounts, in the appropriate technology literature, of attempts to introduce new technologies, but, unfortunately, they have not been reported in sufficient detail to be useful to this study. This is particularly disappointing in the case of studies which observed the introduction of a technology over a long time, such as many of those in "Experiences in appropriate technology"(153)

A few theses have been written on case studies of the introduction of new technologies to underdeveloped countries. Notable among them, and relevant to chapter 6, is that by de Wilde(154), who studied small-scale rural production units, especially strawboard factories, in Sri Lanka. This is discussed in chapter 6.

Apart from case studies, the more general literature on appropriate technology and technology transfer tends to be concerned with issues other than those most pertinent to the studies in this thesis. Much of the appropriate technology literature tends to be prescriptive rather than analytic, aiming to provide criteria of

appropriateness, handed down from upon high, like Moses' tablets(e.g.155,156,157). Technology transfer literature frequently considers this from the viewpoint of obstacles set up at the supply side, and hence concentrate upon institutional mechanisms for overcoming difficulties in the diffusion of ideas from developed to underdeveloped countries(158,159,160,161). The interactions between the transferred technology and the society into which it is introduced are often considered, if at all, as one way processes: the impact of technology upon society or the impact of society upon the transfer of technology. An exception is Reddy(162) who considered the long term dynamics of the interaction between successive technical and social changes in a society: this thesis analyses the short term dynamic interactions between a specific technology and society during its introduction into the society.

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### CHAPTER THREE

#### "Top Board" - a study in failure

Articles which consider the appropriateness of a technology often resort to a list of criteria - the more criteria the prospective technology satisfies, the more appropriate it appears to be(1,2,3,4). In such lists the use of local resources is always among the first criteria. Other considerations often included are the upgrading of wastes, import substitution, production of building materials and employment creation (either directly or in secondary industries). Such criteria are linked to development models of balanced development in which are balanced the aims of increased production, reduced economic dependence and satisfying basic needs.

Would the production of particleboard from bagasse on an island such as Mauritius be an appropriate technology under these criteria? It uses a local raw material, a certain proportion of which is surplus to the sugar factories requirements and so is waste. It produces panels for use in furniture and construction, so helping to satisfy a basic need. It substitutes imported plywood where there is no possibility of local plywood production (because of a general shortage of timber). Its use as panelling for cheaper furniture produced in small workshops could stimulate employment in these. On these criteria such an industry is a prima-facie example of an appropriate technology.

In September 1971, the first particleboards made in Mauritius from bagasse left the factory set up by the Universal Board Co. Ltd. at St. Antoine. The board was given the trade name of "Top Board"(5).

The Universal Board Co. Ltd. went into voluntary liquidation in June 1979, with substantial accumulated losses.

This presents an example of an "appropriate technology" which failed. Unless we choose to enter a circular argument by saying that as it failed it was not appropriate, we need to examine this failure to understand how it happened and where this leaves the concept of an appropriate technology.

#### **1. Origins of the plant(5,6,7,8).**

While the idea of starting a particleboard plant based on bagasse had long been considered in Mauritius(9), the first concrete steps to achieve this were taken by M. Maxime Raffray of the Harel Mallac group of companies. In 1968 (the year of independence), there were favourable conditions for the creation of new industries as secondary industries were being started, there was liquid cash available, and a certain willingness, in both the government and private sectors to create industries off the beaten track. In looking for industrialization projects which would enable him to take advantage of these conditions, M. Raffray looked at the use of bagasse, which was freely available at most of the sugar factories. He claimed another of his objectives was to create jobs and save on foreign exchange(5). He chose to make particleboard from bagasse, given the conditions already mentioned and an increasing world demand for particleboard.

On approaching the government he was offered a development certificate, conferring important tax advantages, and participation by the Development Bank of Mauritius, in the form of a long-term loan. Thus encouraged, he arranged a market survey, approached equipment producers and set about organising the capital to finance the project.

The market study was limited to finding out the total imports of plywood and particleboard, and estimating from this that there was a market for 1200 t annually in 1970 rising to 3500 t in 1979. Assuming similar prices for the particleboard and imported plywood, at the prices then practised by the plywood importers a 3750 t/a particleboard factory was estimated to be able to break even if 600 t/a could be sold. Note in passing that the plywood price used for this calculation was the market price less an assumed wholesaling margin rather than the c.i.f. price.

The plant chosen was the smallest then commercially available, considered in the industry as "small-scale"; even several case studies for an FAO portfolio on small-scale panel plants chose minimum capacities of 3640 t/a(10) or even 4660 t/a(11) of 19 mm, with possibilities of expansion later. Plants of 1000 t/a capacity, expandable to 3000 t/a were not produced.

As M. Raffray said in the PROSI interview(5), he looked for capital from the raw material suppliers (the sugar estates), the plywood importers (who were appointed wholesalers for the particleboard), the Development Bank of Mauritius, the Mauritius Commercial Bank, an insurance company and the public in general. Although more than two hundred investors subscribed to the issue, the main shareholders were

Harel Mallac, St. Antoine sugar estate and the wholesalers. The Development Bank of Mauritius granted long-term secured loans of Rs1.8 M, and the Mauritius Commercial Bank granted overdraft facilities. The loans, together with Rs2 020 070 of shares were not enough to finance the building, equipment and furniture, which came to Rs4.5 M. In consequence they had to take on a suppliers credit of Rs1.6 M from Siempelkamp GmbH covering half the cost of the plant and machinery. This loan was in Deutsche Mark at the bank rate (about 8-10%), over five years. During these five years the rupee was tied first to the pound sterling then to the special drawing right, both of which depreciated against the Deutsche Mark. So the Universal Board Company was placed in the position of having to pay back Rs2.5 M on the loan. Even with this loan only Rs 920 k was available for working capital; beyond this amount it had to be financed by a bank overdraft. Such a small provision for working capital turned out to be inadequate, as shown by the value of the total stocks held in June 1976 - this was Rs1771 k(7). Details of the fixed assets and the capital raised are given in appendix 3.

The factory was built alongside St. Antoine sugar factory, to use their bagasse directly. It was operated by people from St. Antoine sugar factory under a management contract to the Universal Board Co., while the financial management was based in the Harel Mallac headquarters. The sales were handled by the six plywood importers and Harel Mallac. The plant was ordered in 1969, began its first production in September 1971 and made its first sales in November of that year.

From then on the enterprise was beset with problems, as may be seen from figure 3.1, which shows the annual sales compared with the

production capacity of the factory. Note in passing that the sales for 1977/8 were only 742.77 t according to the monthly sales figures provided by M. Raffray's secretary, although in the PROSI Bulletin interview(5) M. Raffray stated that 1200 t were sold that year.

Why did the Universal Board Co. sell so little while the market for panels rose from 1200 t/a in 1970 to 3500 t/a in 1978?(5) To understand this it is essential to study each factor in turn, as follows:

i. Technical factors:

The quality of the board,  
the technology of use, and  
the production cost.

ii. Marketing factors:

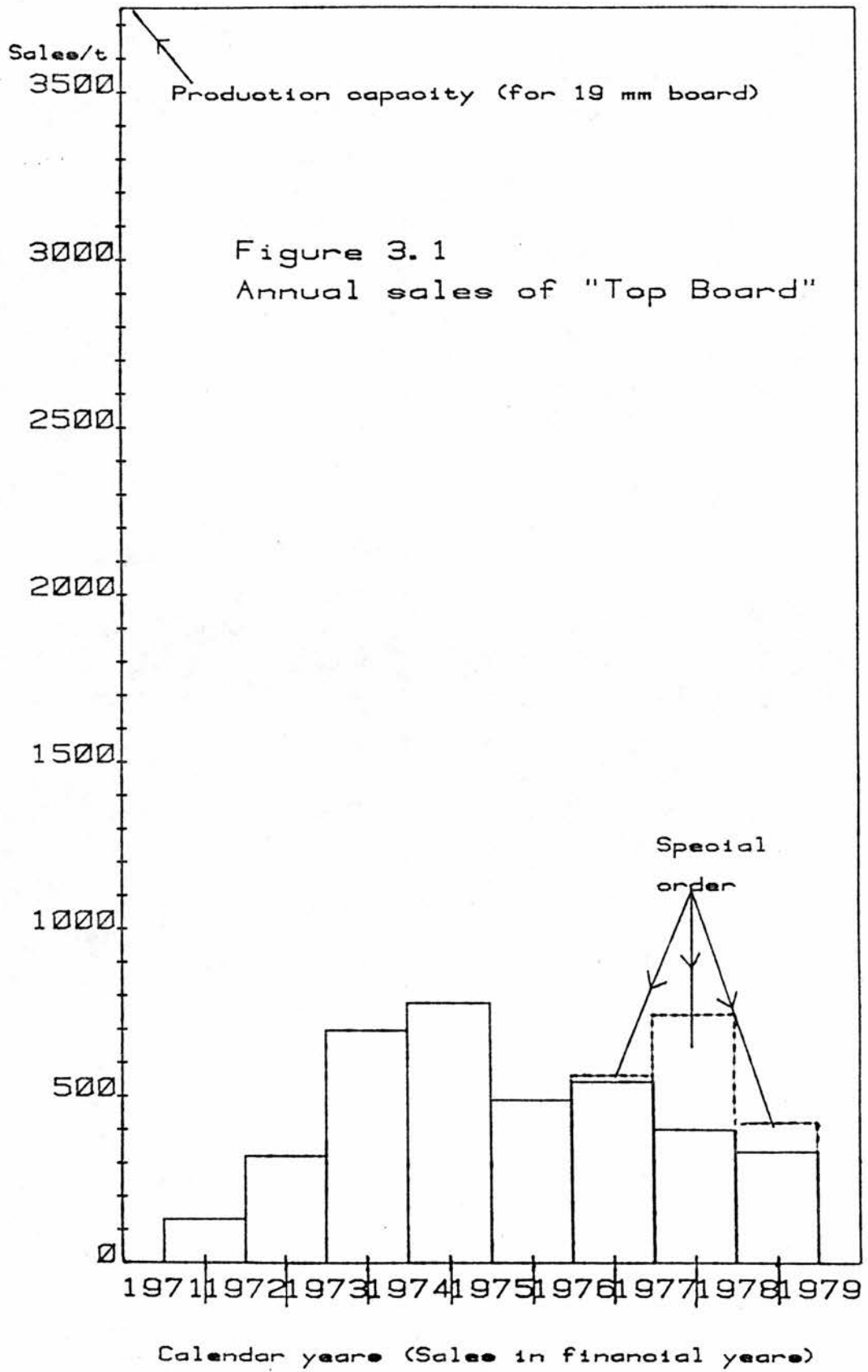
Uses for the board,  
competition with plywood,  
the role of the wholesalers, and  
the role of the government.

iii. Financial factors:

The DM loan,  
the special loans, and  
the overall profitability.

## 2. Technical factors

To consider the various technical factors which may have been involved in the failure of the project, it is necessary to describe





the production process.

Figure 3.2 shows a pile of bailed bagasse outside St. Antoine sugar factory. This stock was used by the particleboard factory outside the cane crushing season. It was made up from bales produced during the season at St. Antoine sugar factory or purchased from other sugar factories. During the crushing season the bagasse was taken directly from St. Antoine sugar mill. In this condition the bagasse contained about 50% water, 10% pith and 10% dirt(12,13) both of which have to be removed as only the fibre from the bagasse provides the strength needed in the particleboard.

Figure 3.2  
Storage of  
bagasse in  
bales out-  
side St. An-  
toine sugar  
factory for  
use in the  
particle-  
board plant.



The wet bagasse from the mill was first passed over a rotating screen for partial wet depithing. The wet pith was returned to the sugar factory to be burned in the boilers, in this way freeing more surplus bagasse. The partially depithed bagasse was then broken up by rotating knives until it could pass a screen of 20 mm x 20 mm holes. This equipment can be seen in figure 3.3 (behind the workers, without masks, breaking up bales). The bagasse was then sent to the particle-

board factory by conveyor (figure 3.4) where it was stored in a 20 m<sup>3</sup> silo. At this stage the pith and dust content had been reduced from 34.9% to 8.5%(12).

Figure 3.3  
Rotating  
knife  
bagasse mill  
behind work-  
ers breaking  
up bales by  
hand.



Figure 3.4 Depithed and  
milled bagasse at entry to  
particleboard mill.

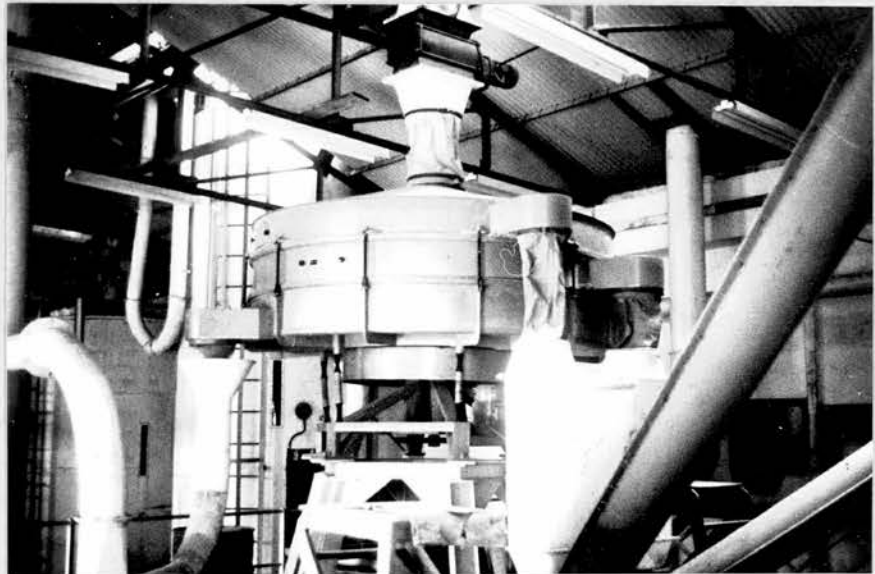


The bagasse was then dried in a pneumatic jet drier in which the bagasse and hot gases travelled in a spiral path allowing good heat and mass transfer and hence a short retention time (30-180 s). The drying gases were a mixture of recirculated gas and the combustion

products of a fuel oil burner. When the burner temperature reached 600 °C the furnace feed was changed to a mixture of fuel oil and bagasse dust, so saving oil.

The dried bagasse was passed through a wing beater mill (a type of hammer mill), where the remaining pith cells were loosened from the fibre bundles, to a vibrating screen (figure 3.5), where it was separated into coarse and fine fibres and pith by screens with 2 mm and 0.6 mm square holes. Typically the bagasse was separated into 27.7% coarse particles, 63.8% fine particles, and 8.5% pith and dust(12). The pith and dust were burned in the bagasse drying furnace, the coarse particles were used in the core of the particleboard, and the fine particles were used in the surface layers of the particleboard (and also in the core when thicker boards were being produced, as the core made up a larger proportion of the weight of the thicker boards).

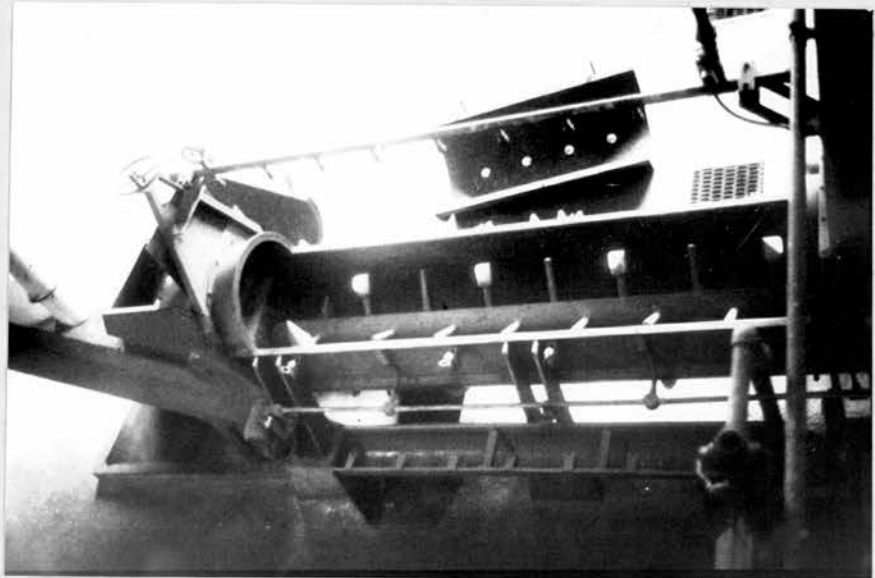
Figure 3.5  
Vibrating  
screen for  
dried  
bagasse  
separation.



Each stream of particles was separately mixed with a prepared glue mixture in continuous flow mixers (see figure 3.6). Urea-

formaldehyde resin was used as, although it was not waterproof, it was much cheaper than phenol-formaldehyde resin. Even the cheaper urea-formaldehyde resin made up 30% of the direct production costs of the particleboard(5). The glue was mixed with paraffin wax to retard water absorption, extra urea to react with excess formaldehyde in the resin (necessary for the curing reaction) and a fungicide. Fungicide was not added to the first boards produced, resulting in massive fungal growths on boards used on the humid central plateau of the island. After experiments with different fungicides(12), a fungicide known as "Xyligen 30F", produced by Bayer, was chosen. On boards so treated fungus only grew when used in parts of the island where the humidity was so high that fungus readily grew on wood itself.

Figure 3.6  
Bagasse/glue  
mixer, open  
for maintenance.



The glued bagasse particles were then taken to two spreading machines (figure 3.7) (one for fine particles, one for coarse) under which passed two trays on which was formed a mat of glued particles. Figure 3.8 shows the principle by which the mat was built up in layers of fine, coarse, coarse and fine particles to produce a three layer board. As operated in this factory, the final result was a mat



of rather uneven thickness as shown in figure 3.9.

Figure 3.7  
Overall view  
of the mat  
forming sta-  
tions, with  
separated  
feeds for  
fine and  
coarse par-  
ticles  
entering at  
the top at  
each end.

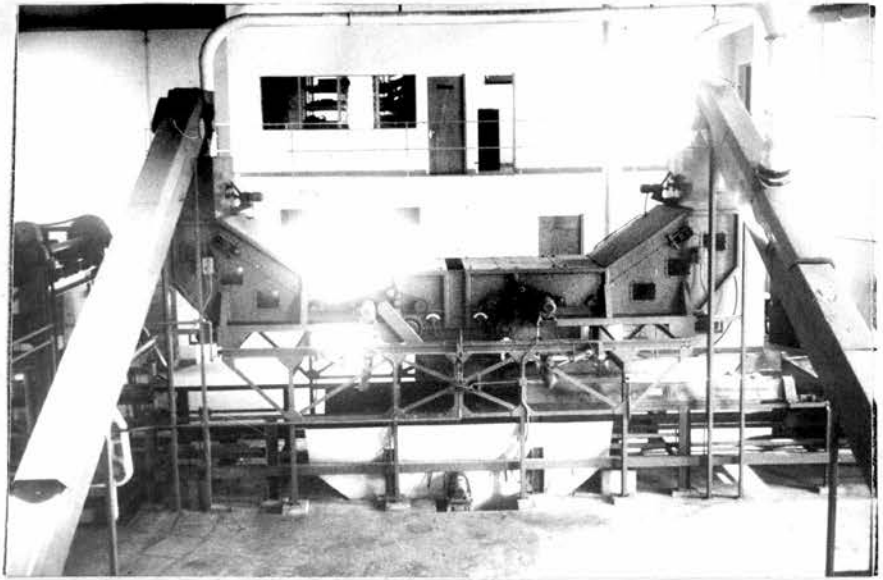
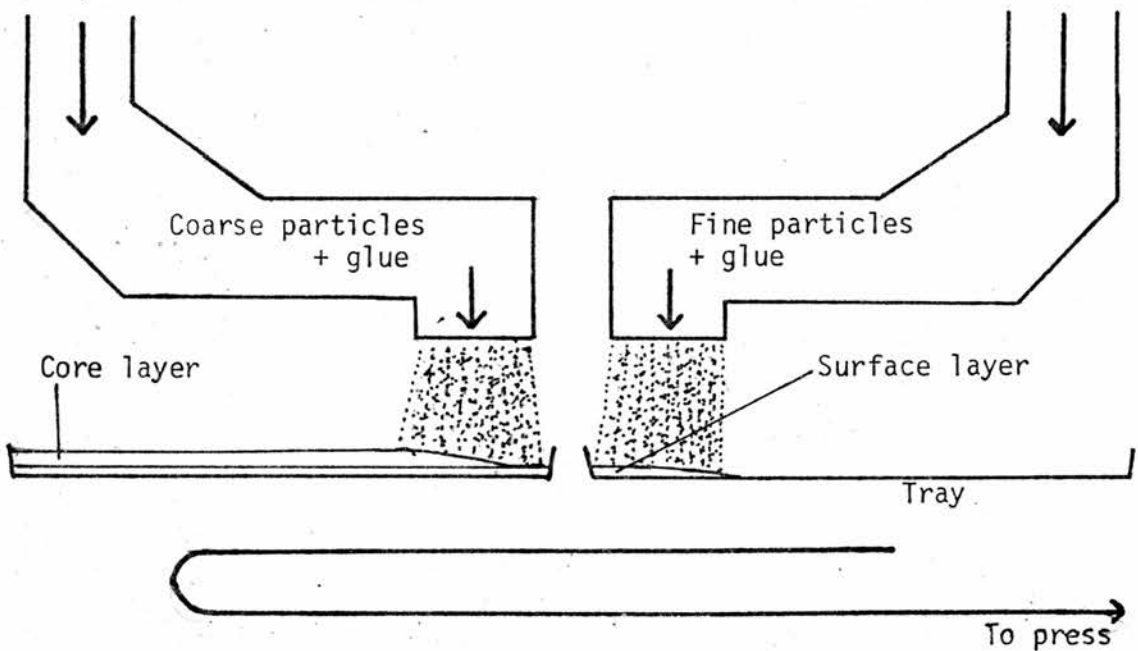


Figure 3.8 Operating principle of the mat forming station.



The two trays were then fed into the double opening press. This press had platens heated by hot oil at 150 °C. When the bagasse mat came into contact with the platens steam, formed from the 10% moisture left in the bagasse, passed to the centre of the mat

Figure 3.9  
Formed mat  
on tray  
ready to  
enter the  
press. Note  
the uneven  
surface.



Figure 3.10  
Particle  
board press,  
opening,  
showing  
pressed  
boards.



transferring the heat from the platens. At the same time the resin cured and the bagasse was compressed. When the pressing conditions were properly set, the board maintained the same dimensions ( $\pm 2\%$ ) when released from the press. The cycle times used varied from 2.5 to 10 min. The press, opening to show the pressed boards, is shown in figure 3.10.

The boards were then stacked horizontally for several days to

allow the curing process to go to completion, following which they were trimmed and sanded on a drum sander. The sander should produce boards of even thickness—in fact, owing to the uneven mat formation, uneven boards were produced. This created difficulties for users such as Boboulo (a factory which made furniture mainly from Top Board)(14).

What quality of board was produced by this process? Figure 3.11 shows the results of tests carried out at Hesch's laboratory in Germany(15), and at the University of Mauritius by the author. For comparison figure 3.12 shows test results on specimens of bagasse particleboard made elsewhere, and figure 3.13 the DIN standards for (wood-based) particleboard.

Figure 3.11 Physical properties of "Top Board".

Tested by:	Hesch					Newman	
No. of samples	11	11	11	11	11	3	2
Thickness/mm	<b>4.33</b>	5.87	<b>13.27</b>	19.04	<b>30.25</b>	<b>4.61</b> +0.23	<b>19.6</b> +0.1
Density/kg m <sup>-3</sup>	770	670	640	<b>530</b>	<b>420</b>	<b>630</b> +40	<b>575</b> +25
Bending strength/MPa	27.1	22.4	<b>17.0</b>	<b>14.8</b>	9.5	<b>14.7</b> +2.9	<b>13.1</b> +0.4
Bending modulus/GPa	-	-	-	-	-	<b>1.51</b> +0.29	<b>1.67</b> +0.15
Tens. strength/MPa	1.26	0.91	0.47	0.36	0.22	-	-
Swelling/% - 2 hr	3.1	4.5	1.4	2.5	3.5	-	-
24 hr	6.4	8.7	6.3	5.0	5.2	-	-
Water abs./% - 2 hr	8.9	14.9	25.4	55.9	88.5	-	-
24 hr	22.3	36.5	66.3	89.0	118.4	-	-

Note: figures in **bold** type are outwith the DIN standard or below the design density.

Sources: tests carried out by the author at the University of Mauritius in 1976 and earlier tests carried out at Hesch's laboratory(15).

Compared to the DIN standard and the results achieved in Vermaas' selected particleboard plants, the quality of "Top Board" was lacking in several respects. Not only was there poor control of the



Figure 3.12 Physical properties of bagasse particleboards.

Origin:	Indonesia	India	Cuba		Cuba		
Thickness/mm <sub>-3</sub>	12	16	3.3	3.1	16.2	15.6	16.8
Density/kg m <sup>-3</sup>	680	625	740	772	663	703	657
Bending strength/MPa	27.0	22.3	23.9	25.5	20.9	27.6	25.0
Tens. strength/MPa	0.41	0.51	0.72	0.70	0.46	0.57	0.51
Swelling/% - 2 hr	2.8	6.1	3.1	3.2	3.5	2.6	3.0
-24 hr	15.3	-	-	-	13.0	-	-
Resin content/%	8.5	8.5	12	12	8.5	8.5	8.5

Source: Vermaas(16).

Figure 3.13 DIN 68761 (Sept. 1973 issue) for particleboard.

Thickness ranges/mm	All	<13	13-20	20-25
Tolerances/mm				
- length & width	+3			
- thickness	+0.2			
Moisture/%	9+3			
Bending strength/MPa		>19.6	>17.7	>14.7
Tens. strength/MPa		>0.39	>0.34	>0.29
Swelling (2 hr)/%	<6			

Source: Fahrni(11).

mat thickness, but this carried over to affect the sanded thickness. The bending strengths of the 13 mm and 19 mm boards were outwith DIN 68761, while the bending strength of 4 mm board declined from 27.1 MPa in 1972 to 15±3 MPa in 1976. There are no standards for the elastic modulus in bending, as this is only important for a limited number of applications\*. However, in these applications the use of "Top Board" was severely limited, as the modulus was only about 1.5 GPa, much lower than that of spruce (14 MPa) or oak (12 MPa)(17).

\* One such use is in table tennis tables. Throughout Mauritius one could see sagging table tennis tables made of "Top Board", and only the foolhardy stood on them to change a light bulb.

Otherwise the properties were up to standard and comparable with those of the bagasse particleboards mentioned by Vermaas.

The low strengths were related to the low densities of the boards. According to the production programme of the factory(7), the 4 mm board should have had a density of  $750 \text{ kg/m}^3$ . The samples tested at Hesch's laboratory had a density of  $770 \text{ kg/m}^3$  and an adequate bending strength of 27.1 MPa, whereas the samples tested by the author, in 1976, had densities of  $630 \pm 40 \text{ kg/m}^3$  and bending strengths of only  $15 \pm 3 \text{ MPa}$ . It appears that in 1976 the factory was producing board with an inadequate supply of particles and/or glue for the density and thickness required, as also the density of the 19 mm board was below the planned level of  $600 \text{ kg/m}^3$ .

The weakness of the board was of little consequence to most Mauritian users, as "Top Board" was mainly used as panelling in wooden framed furniture, or in other non-load bearing applications such as in false ceilings or insulating panels. Typical cheap furniture in Mauritius uses the thinnest plywood available as a base for painted panels to give the appearance needed at the lowest cost - it does not matter if you can kick holes in it.

For other potential uses, the mechanical properties of the board are more important. One such use was the manufacture of tea chests from "Top Board". Tea chests have to resist dockside handling and chafing on ship, and also support the weight of other chests stacked above them. As Hesch wrote (in a letter to the author(18)):

Another mistake I remember, was to reduce the quality of the boards in order to save costs, so that a large customer, producing tea chests from bagasse particleboard, finally decided to return to plywood.\*

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Another such use was in partitioning of offices and houses. In general, "Top Board" was not used for this, partly through a relative lack of rigidity, but mostly through a lack of knowledge of how to use it. Although most Mauritian architects shunned the particleboard, the European architects employed to design the new Registry House in Port Louis were quite happy to use particleboard in Mauritius. They tested the product and specified thicker particleboard (mostly 49 mm), to compensate for the somewhat poorer mechanical properties.

But for small furniture makers, the bending strength and modulus were of less importance. More important for them was the difficulty in working with particleboard. It cannot be nailed or screwed as the board will often split. Joints have to be glued or dowelled, thus spreading the forces over a large contact area. There is greater wear of saws because of the silica in bagasse, so they had to sharpen their saws more often, except for those who bought tungsten carbide tipped saws. Any visible part of the particleboard has to be veneered, as painted particleboard is very obviously painted chipboard and not plywood. Furthermore, for good moisture resistance all surfaces of the particleboard must be sealed, either with glue or veneer. Some small producers bought the board and then stuck on veneers by hand(7), while one large factory, Boboulo, had its own veneering equipment. The Universal Board Co. also produced a little veneered board, but sold little: (only 2.5% by value of the sales over the lifetime of the plant(19))

Particleboard use can be simplified if the first processing

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\* In fact, the tea chests were made by the Universal Board Co. and sold as complete tea chests to this customer.

steps are carried out at the factory, leaving the assembly of veneered, cut-to-size boards to the furniture manufacturer or builder. This was an early recommendation of Dr. Hesch to M. Raffray. As Hesch said in a letter to the author(18):

As a matter of fact, I was really preaching that processing of the particleboard to semi-finished and finished products has to be added to the particleboard plant, especially in a market where (sic) particleboard is not yet introduced. My advice was finally followed (sic) to a certain extent. Machinery suitable to produce prefabricated door, table tops, cut-to-size veneered and unveneered particleboard and so on was purchased, but as far as I know never put into operation. This was one of the serious mistakes of the company. Utilization of particleboard requires special machinery and know-how, which could not be expected to be available at the Mauritian consumers. It was, therefore, imperative (sic) for the success of such a project, that operations requiring expensive and sophisticated machinery were done at the factory, so that the carpenters and house builders could restrict their activities mainly to a kind of assembly and fitting, where neither complicated know-how nor expensive machinery were required.

In the absence of such semi-finished products people bought the raw particle board. On trying a sheet they would hammer a nail into it, and find that either it pulled out easily or split the board; cut it with an old saw, and find that it took ages; leave it in a damp workshop, and find that the board swelled or even that fungus grew on it (for the first boards produced). Here was a disincentive to the use of particleboard in Mauritius. As we shall see in the section on the marketing of "Top Board", no attempt was made to teach the users how they could use particleboard: so only the most persistent carried on until they had found this out by trial and error or by copying other users such as Boboulo. To quote Hesch again:

I had also arranged with the German government for a German carpenter with teaching abilities to go to Mauritius to arrange training courses for carpenters and do sales promotion by teaching the people how to apply particleboard in the right manner. The German government expected from the company in Mauritius to contribute in a certain percentage

to the costs for such expert. The company did not accept the proposal of the German government and a good chance to improve the situation was lost.

The only incentive which might have encouraged users to be more persistent would have been a low price. In fact, the margin between particleboard and plywood prices was often quite small. Before the factory started production, thin plywood had been selling for Rs0.48-0.50/ft<sup>2</sup> (Rs 5.3/m<sup>2</sup>). When "Top Board" became available with its thinnest grades selling for Rs0.42/ft<sup>2</sup> (Rs 4.5/m<sup>2</sup>), the plywood prices dropped to the same(6). The details of selling prices will be discussed later, for now the technical component of this - the production cost - will be considered.

Lam Wai Shung(12) calculated the production cost of 19 mm particleboard from the physical inputs used to produce 3750 t/a or 1750 t/a particleboard. As the production levels never reached 1750 t/a, and 19 mm particleboard only made up one quarter of the sales from 1976 to 1979, the production costs have been recalculated to take account of reality. The object of this recalculation is to contrast the idealised analyses often made in project proposals and industrial profiles(12,10,20) with the material conditions of operation of the factory. In the Third World idealized analyses are even less adequate than in developed countries.

These calculations can be found in appendix 3. Firstly, the sales figures were analysed to find out the distribution of sales by the thicknesses of boards sold. The distribution was consistent from 1966 to 1979; on average 11% of the weight of board sold was 4 mm thick, 19% was 6 mm, 36% was 13 mm, 4% was 16 mm, 26% was 19 mm, 1% was 25 mm, and 3% was 30 mm thick.

These proportions exclude the special order for

the Registry House, which mainly consisted of 49 mm board. So the average thickness sold was 13 mm. This is less than the European average of around 15 mm(21). No doubt this was due to the Mauritian sales being mainly to the furniture market, which uses thinner particleboard than does the construction industry.

The board thickness affects the production cost in several ways. Less weight of thinner board can be pressed per hour, so increasing the time related costs such as the energy required to heat the presses and the labour charges, and reducing the production capacity below 3750 t/a. Also more raw material is wasted in the sanding, and more resin, urea and fungicide are needed as a greater proportion of the board is made up of surface layers.

Based on this mixture of thicknesses, and unit costs from Lam(12) and Raffray(7,8), the variable production costs were calculated for mid-1974, late 1979 and the financial years (July to June) 1975/76 and 1977/78. The proportionate contributions of the different costs to the total variable costs is shown in figure 3.14.

It can be seen from figure 3.14 that the resin, fungicide and electricity alone accounted for around 75% of the total cost, each item costing more than the labour (about 12%) or the bagasse (up to 5%). As the resin, fungicide and the fuel oil to produce electricity in the power stations are imported, this can not be considered a significant import substituting industry.

It should be noted that these are only approximate percentages, as they are based on a model calculation rather than the accounts. A comparison of the results of this calculation with the cost of production figures in the accounts (in appendix 3) showed that the model

Figure 3.14 Importance of different items in the variable costs of producing particleboard at St. Antoine.

%	1974	1975/76	1976/77	1979
Bagasse	0.0	5.1	4.4	5.4
Resin	40.9	35.0	35.0	30.5
Paraffin wax	1.5	1.3	1.2	1.3
Emulsifier	1.0	1.0	0.9	0.7
Ammonia	*	*	*	*
NH <sub>4</sub> Cl	0.7	0.7	1.3	0.7
Urea	0.6	1.2	1.3	0.7
Fungicide	20.1	20.0	19.2	17.4
Sandpaper	1.9	2	1.9	1.7
Raw Materials	66.7	66.3	64.7	59.1
Fuel oil	5.1	5.5	5.4	8.4
Electricity	17.3	16.8	17.5	21.4
Services	22.4	22.3	22.9	29.8
Labour:				
skilled	3.8	3.9	4.3	4.0
semi-skilled	7.2	7.6	8.2	7.8
total	11.0	11.5	12.5	11.8
Total	100.1	100.1	100.1	100.0

\* Less than 0.5%.

gave a good estimate of the raw materials costs, underestimated the fuel oil cost by a factor of two, and slightly underestimated the fuel oil cost†.

The production cost breakdown in the accounts(19) does not specify the contributions of different raw materials to the cost, but includes other costs such as maintenance and insurance. This breakdown is presented in figure 3.15 and figure 3.16. For ease of comparison with figure 3.14, yet allowing the same table to be used to

† Including the fixed maximum demand charge.



show the increase in costs over the five financial years, they are presented as indices, with the total production costs (excluding depreciation) in 1973/4 set to 100. As some of the items are a mixture of fixed and variable production costs (e.g. the management fee and the electricity cost), two tables have been produced, one based on the unit costs in Rs/t board produced (figure 3.15), the other on the total production costs for the financial year (figure 3.16).

Figure 3.15 Analysis of unit production cost.

	Index: 1973/74 total cost/t = 100					% increase
	'73/4	'74/5	'75/6	'76/7	'77/8	in 5 years
Raw materials	48.5	42.8	72.6	74.3	130.1	169
Management fee*	10.4	22.3	36.5	87.5	43.8	323
Maintenance	4.4	4.4	4.9	10.6	12.4	179
Insurance	3.6	2.3	3.1	7.8	5.5	⊕
Fuel & oil	9.8	9.7	11.6	14.4	22.0	124
Electricity	22.0	15.0	23.9	38.5	39.1	77
Sundry costs	1.3	-	-	-	-	-
Total	100.0	96.5	152.6	233.1	252.9	153
Production/(t)	505	845	1042	516	835	

\* Includes labour, factory management, water, lubricating oil and grease, insurance of bagasse and transport.

⊕ Not sensible to calculate as a variable cost.

Source: Universal Board Co. accounts(19).

Considering the cost breakdown in each year in figure 3.15 and figure 3.16, it can be shown that over these five years, the direct production expenditures were divided as follows:

Raw materials = 45.5%  
 Management fee = 23.1%  
 Maintenance = 4.3%  
 Insurance = 2.5%

Figure 3.16 Analysis of annual production costs.

	Index: 1973/74 expenditure = 100					% increase
	'73/4	'74/5	'75/6	'76/7	'77/8	in 5 years
Raw materials	48.5	71.6	149.8	76.0	215.2	⊕
Management fee*	10.4	37.3	75.3	89.4	72.4	600
Maintenance	4.4	7.5	10.0	10.9	20.4	365
Insurance	3.6	3.7	6.4	8.0	9.0	146
Fuel & oil	9.8	16.2	24.1	14.8	36.3	⊕
Electricity	22.0	25.0	49.4	39.2	64.8	194
Sundry costs	1.3	-	-	-	-	-
Total	100.0	161.4	314.9	238.3	418.1	318
Production/(t)	505	845	1042	516	835	

\* Includes labour, factory management, water, lubricating oil and grease, insurance of bagasse and transport.

⊕ Not sensible to calculate as a fixed cost.

Source: Universal Board Co. accounts(19).

Fuel & oil = 8.2%

Electricity = 16.3%

Sundry costs = 0.1%

It can be seen that apart from the raw materials and electricity costs, the management fee was also an important component of the production cost. This included the wages and salaries of the workers and supervisory staff at the particleboard factory, plus bagasse insurance, transport, water and lubricating oil and grease.

In his interview in PROSI Bulletin(5), Raffray included among the problems faced by the Universal Board Co.:

Augmentations spectaculaires et certainement imprévisibles des coûts de production causées d'une part par la hausse du coût des matières premières importées et, d'autre part, par les augmentations locales . . . \*

\* Spectacular and certainly unforeseeable increases in the pro-

He selected certain examples of price increases over five years. These are reproduced in figure 3.17, together with similar information provided by his secretary in 1980(8).

Figure 3.17 Selected price/production cost increases according to Raffray.

	% increase in 5 years	
	(a)	(b)
Raw materials	150	170
Wages and salaries	760	600
Fuel oil	60	192
Electricity	112	80
Insurance	100	150

Sources: (a) - figures provided by Raffray's secretary in Jan. 1980(8). (b) - from Raffray's interview in PROSI Bulletin(5).

It seems odd that there can be such differences between these two lists of price increases, and between them and the figures in figure 3.15 and figure 3.16. In fact, these selected price increases were not all measured in the same way. Some are increases in the cost per unit of the item, some are increases in the contribution of that item to the cost of production per tonne board, and some are increases in the contribution of a given item to the annual production cost. This mixture of measurements confuses the effects of external increases of prices of inputs to the process, the efficiency with which these inputs are used within the company, and the production level.

The figure of 112% increase over five years in figure 3.17 is

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duction costs caused on the one hand by the rise of the cost of imported raw materials and, on the other hand, by local price increases (author's translation)

the increase in electricity prices per kWh consumed over the period (see figure A3.6), whereas that of 80% is approximately the increase in the electricity cost per tonne board produced (see figure 3.15). As the maximum demand charge also rose by 127% over the same period (calculated from (22,23) ), the 80% increase in cost per tonne board represents an increase in the efficiency of electricity use in the factory, partly due to the higher production level reducing the effect of the fixed maximum demand charge on the unit production costs.

The fuel oil prices did increase by 190% over these years as indicated by Raffray(5) (187% from figure A3.6, 192% from figure 3.17), but the fuel oil element of the unit cost of the boards only rose 124% (see figure 3.15). This shows that the factory improved the efficiency with which it used fuel oil, probably an effect of running the factory on a multishift basis continuously until the production requirements had been met, and then shutting down the factory until the stocks had been further depleted. This enabled more bagasse dust to be burned in the furnace of the bagasse dryer than on one shift operation, as only fuel oil could be burned until the furnace temperature had reached 600 °C. The other figure for fuel oil price increase in figure 3.17 must refer to a different five year period. For between the financial years 1973/74 and 1976/77 the fuel oil cost per tonne board rose by only 46%.

Raffray's figure of 170% increase in the cost of raw materials in five years (figure 3.17 column b) corresponds to the increase in the cost of raw materials per tonne board produced in figure 3.15. However, the actual prices of the raw materials rose by less. Based on the actual prices of each raw material and Lam's model(12),

adapted to the thicknesses of board sold, the increase in the prices of the raw materials was only 53% (see figure A3.7). As most of the increase in the raw material cost per tonne board occurred between 1976/77 and 1977/78 (the increase from 1973/74 to 1976/77 was only 53%), and as 1977/78 was the year in which most of the special order for the Registry House was produced, it is likely that the higher quality standards required for this board, and the differences in thickness of the boards (mostly 49 mm), led to an increased use of raw materials per tonne board, and/or use of more expensive raw materials than normal.† As noted previously, according to Hesch the Universal Board Co. had reduced the quality of board in order to reduce the production costs.

The figures of 600% increase in wages and salaries and 150% increase in insurance premiums quoted by Raffray (see figure 3.17), are the increases in the annual management fee and insurance premiums respectively. The management fee included not only the wages and salaries of the workers and management supplied by St. Antoine S. E. to the particleboard factory, but other charges assumed by St. Antoine, bagasse insurance, transport, water and lubricating oils. It is not clear whether this fee should be considered a fixed or variable cost, as when the particleboard factory was not operating the workers worked in the sugar factory. So should only the wages for the periods when the particleboard factory was operating have been charged to the management fee, or the wages for the whole year on the basis that the particleboard factory was more often shut down outside

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† I do not know the composition of the board produced under the special order, only the normal composition as described by Lam(12). The order may well have specified a different, or greater quantities of, fungicide, for example.

the cane crushing season, when there was little work in the factory for these men? Without knowing the details of the management contracts, it is impossible to tell. From figure 3.16 it can be seen that the management fee rose rapidly until 1975/76 and then remained approximately constant, on an annual basis, despite changes in the quantities produced. So possibly it became to be thought of as a fixed annual charge, to include the total wage cost plus whatever profit margin was negotiated between the companies. Without such a change in the basis of calculation of the management fee it would be difficult to explain such a steep increase, as the wages of skilled sugar factory workers only increased by 73% in the same period(24).

The insurance cost rose rapidly, no doubt because the large stocks of unsold particleboard which came to be stored in the factory would have been considered a fire hazard by the insurance company. Nevertheless, this was of little importance as on average only 2.5% of the direct production costs were due to insurance premiums.# Again, the maintenance costs only came to 4.3% of the direct production costs, on average. Other proportions were: raw materials = 45.5%; management fee = 23.1%; fuel and oil = 8.2%; electricity = 16.3%.

How important were these cost increases to the profitability of the venture? They must be seen in the context of general inflation, and the rise of plywood prices over the same period. The cost-of-living index rose by 68%(24), while plywood import (c.i.f.) prices rose by 65% from 1973 to 1976 and then decreased in 1977 to give a five year increase of 55%(25), as shown in figure 3.18.

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# Calculated from figure 3.16 - production weighted average 1973-8.

Figure 3.18 Plywood imports (c.i.f. Port Louis)

Year	Value Rs	Quantity m <sup>2</sup>	Price Rs/m <sup>2</sup>	Price index
1970	1652230	437414	3.78	62
1971	1694007	457512	3.70	61
1972	2452233	608456	4.03	67
1973	3917353	648912	6.04	100
1974	6082952	804508	7.56	125
1976	10102685	1023682	9.89	165
1977	11014341	1177947	9.35	155

Source: Mauritius Customs and Excise Reports(25).

So with direct production costs rising faster than the import costs of plywood, the profit margins were being squeezed, particularly after 1976/77 as, up to then, the variable production costs (taken as raw materials, fuel oil and electricity) had kept in step with the plywood cost increases. Further evidence of the sharp cost increase from 1976/77 to 1977/78 is given in figure 3.19 which shows the average production cost (including depreciation) per tonne board sold. In each year old stocks were sold, while some of the production went into stock to be sold later. Since the old stocks were cheaper, this changed the average cost of the board sold from that of the board produced during the year.

As figure 3.19 shows, the average production cost (including depreciation) had increased by only 39% from 1973/74 to 1976/77, and then jumped in 1977/78 to over twice the 1973/74 cost. This is partly a result of a higher allowance for depreciation, but also is the effect of the cost increases discussed previously.

### 3. Marketing factors

As has been shown (in figure 3.1), the factory sold far less



Figure 3.19 Cost of sales, production and average production cost (including depreciation) of "Top Board", 1973-8.

Financial Year	Cost of sales kRs	Sales t	Average cost Rs/t	cost index
1973/74	905	697	1299	100
1974/75	731	779	939	72
1975/76	803	488	1646	127
1976/77	1014	563	1801	139
1977/78	2113	745	2835	218

All calculations to full precision of data, rounded to nearest whole number for presentation.

Sources: Cost of sales from the annual accounts(19), quantities sold from Raffray(8,7), see figure A3.1.

board than it was capable of producing. Was there then no market for particleboard in Mauritius? The best answer to this question can be found by comparing the "Top Board" sales with the imports of plywood, as these competed for several markets. As the Customs and Excise Reports give the plywood imports in square metres, the particle board sales have to be converted to square metres. This has been done by calculating the number of square metres of board which correspond to one tonne for each thickness sold, and then multiplying these values by the proportion of the total sales made up by board of this thickness. The total represents the number of square metres of "Top Board" which on average corresponded to one tonne of board. This comes to  $159 \text{ m}^2/\text{t}$ . (See figure A3.3)

Applying this factor to the annual sales of "Top Board" (see figure A3.1), figure 3.20 has been produced. In this can be seen the very small proportion of the plywood market which had been taken by "Top Board". On a weight basis the market penetration would have been greater, as it was likely that the grades of plywood sold would have been thinner (including 3 mm plywood but very little 19 mm or 30 mm).

Even though a certain proportion of the plywood imports were not substitutable by particleboard, obviously a 15% market penetration was too low.

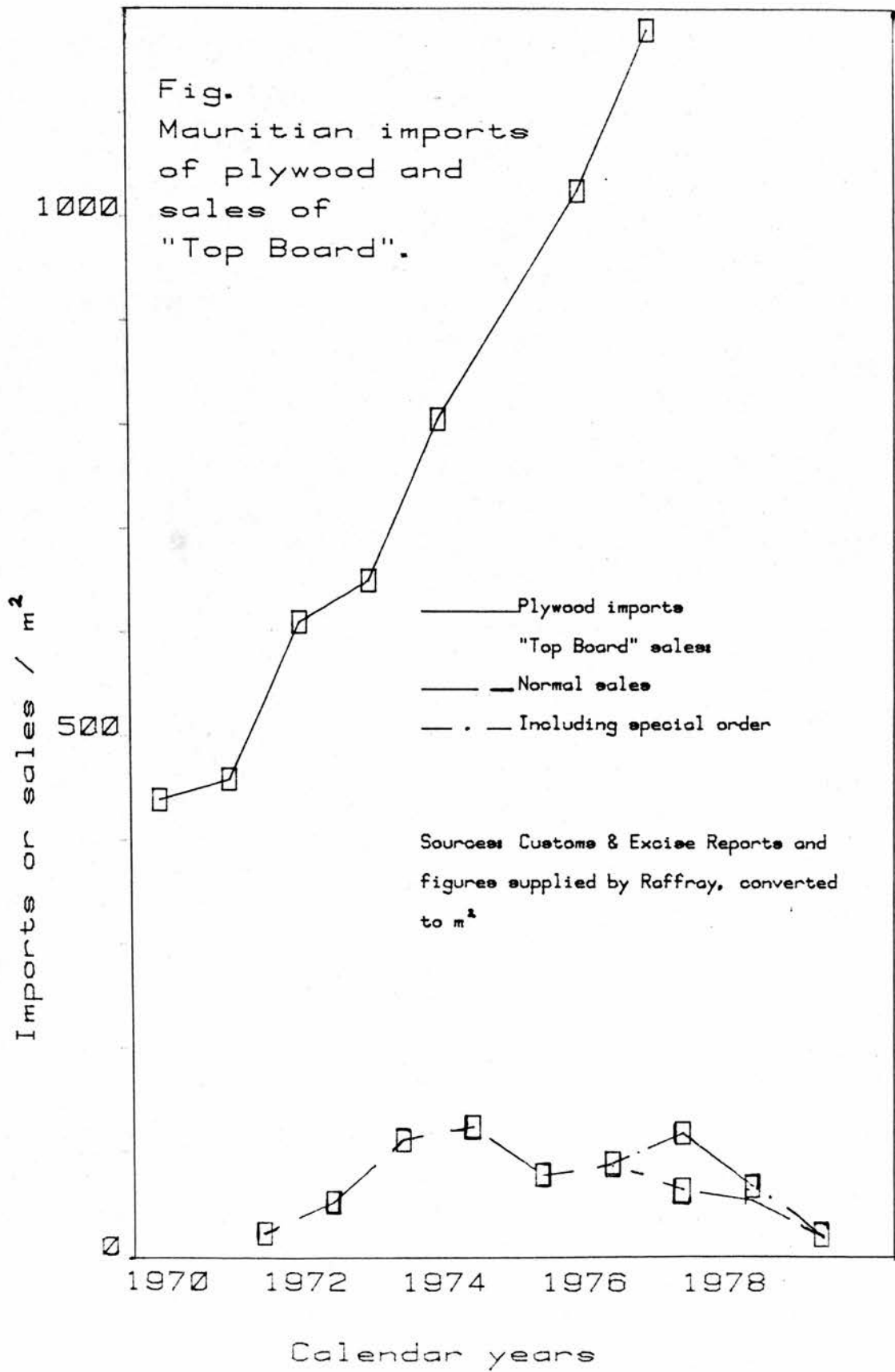
Why did people continue to buy plywood rather than switch to "Top Board"? And as the market was expanding, why did new users not use "Top Board"? To understand this it is necessary to study the interests of the consumers and the sellers. As has been mentioned previously, the consumers were mainly small furniture workshops, who needed the cheapest, easily useable material available. Particleboard is not easily used by people who have never used it before—one has to learn special jointing techniques and to use thicker board if it is required to meet structural loads. As Mauritian furniture workshops usually did all operations manually (e.g. cutting planks with long tenon saws), and often had problems getting really skilled carpenters\* (those who would be able to experiment in the use of new materials), they would have had to be shown exactly how to use the particleboard.

But no attempt was made to do this. Except for 3 months in 1975, the Universal Board Company did not even employ a salesman, who might have been able to help the users learn how to use the product. The only effort made to acquaint users with "Top Board" was newspaper advertising at the beginning (Rs22 k of advertising in 1972 and Rs 14k in 1974(19)). Nor was any attempt made to provide instruction at the warehouses where the board was sold. When a customer arrived at one of these, the following (imaginary) conversation might

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\* For example, Peter Ming had to close a furniture workshop he owned because of difficulties in finding carpenters who were both skilled and conscientious.

Figure 3.20 Mauritian imports of plywood and sales of "Top Board"



have occurred:

CUSTOMER. What's that stuff over there?

SALESMAN. Oh, that's Top Board.

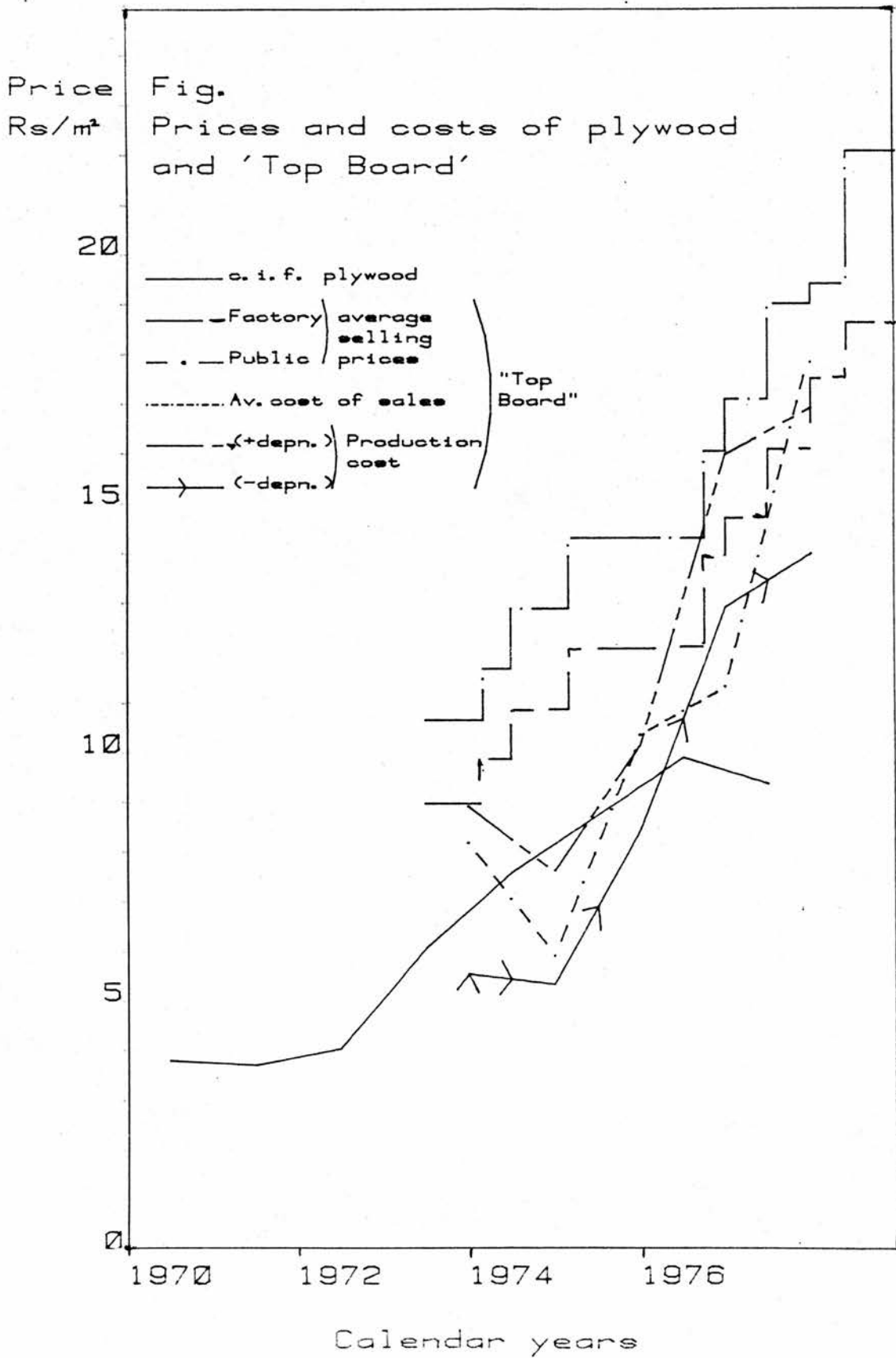
CUSTOMER. I'll have some 3 mm plywood

With such limited information available on how to use the board, and such limited publicity, there was no reason why the users should particularly want to try "Top Board", except perhaps its price. And although its price was always set a little below that of plywood, it was not so low that users would have been encouraged to persevere after initial difficulties.

The selling prices of "Top Board" are given in figure A3.8. These have been averaged according to the mix of board thicknesses sold and plotted in figure 3.21, together with the plywood import (c.i.f.) prices, and the average production costs and costs of sales calculated in the previous section. The plywood import prices have been calculated from the Customs and Excise Reports(25). From figure 3.21 can be drawn three conclusions:

- i. the profitability of the Universal Board Co., as indicated by the difference between the production cost or cost of sales and the factory selling price, declined over the lifetime of the company,
- ii. the "Top Board" price increased faster than the plywood import price, and
- iii. the profits on plywood to the wholesaler were up to Rs3/m<sup>2</sup> higher than the 18.5% margin they received on the

Figure 3.21 Prices and costs of plywood and "Top Board".



particleboard.†

The first point has already been discussed. The second is the crux of the matter, as without a significant price difference or substantial promotion, why should the users persevere? To change this situation of low sales, low plant utilisation and hence low profits, would have required a strong incentive to the users: in the form of lower prices, or an increased sales effort. It is the third point which provides a clue to why such steps were not taken. It is necessary to consider the interests of the sellers, and any differences of interest between the different groups involved.

The group which had the most direct contact with the customer was the wholesalers. The "Top Board" sales were only a small part of their business, amounting to only a fraction of their sales of plywood (as shown in figure 3.20), which itself was only a part of their sales of building materials. Their primary interest was in maximising the profit of their wholesaling operation. From this viewpoint, every square metre of "Top Board" they sold to someone who might otherwise have bought plywood lost them money. Assuming that only half the difference between the factory price for "Top Board" and the import price for plywood was extra profit to the wholesalers, this would have given them an extra Rs750 k on the 500 000 /a# production capacity of the particleboard plant, for selling plywood instead of particleboard.

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† The maximum of Rs3/m<sup>2</sup> assumes that the customs duties and port handling charges are negligible - in fact, the duty was substantially raised after the Universal Board Co. had entered voluntary liquidation.

#  $3750 \text{ t/a}(19 \text{ mm}) \times \frac{660.1 \text{ kg/hr(aver.)}}{763.2 \text{ kg/hr}(19 \text{ mm})} \times 159 \text{ m}^2/\text{t}$

Against this must be put their secondary interest in the Universal Board Co. as shareholders. They were among the preference 'A' shareholders (together with Harel Mallac Ltd. and St. Antoine S. E.)(6,5). So they had contributed some proportion of the Rs1.2 M preference 'A' shareholding. In the context of their total trading or even their annual profits on plywood this was a small investment, perhaps seen as a kind of insurance against possible increases in world plywood prices, or as a means of maintaining control of the total market for boards. Even the Rs1.7 M(8) in special loans they had to contribute when the DM loan from Siempelkamp fell due (after appreciation in the D M against the rupee had changed a Rs1.6M loan into a Rs2.5 M repayment(5) ) was only the extra profit on 2.3 years sales of plywood instead of particleboard. And as this was financed as a loan rather than an extra share issue, they were somewhat protected against the effects of future problems (as loans are repaid before shareholders in liquidations)—so even after this they were not fully committed to the Universal Board Co. in the way that Raffray was, for example.

With so little interest or involvement in the success of the venture, there was no reason for the wholesalers to change their selling methods from their standard practice which was to put the goods in a warehouse and wait for the customers to come to them. This, of course, is a logical way to run an import business (as people had to get the materials somewhere), so keeping overheads on transport and advertising low: but it is not suited to selling a new material, outwith the experience of most people on the island. They might have set up demonstrations on the applications and use of particleboard, have specially trained their warehouse staff in the use of the material,



and imported and sold chipboard screws, hinges and other special fittings which make its assembly so much easier in Europe. They did none of these things.

Although they might have made a logical financial decision not to promote "Top Board" as it reduced their potential profits, there is no evidence that this was a conscious decision.<sup>§</sup> For such active promotion of minor lines is well outside the normal behaviour of the large import companies in Mauritius, aggressive selling and concern over marketing having been more in evidence in the newer Sino-Mauritian companies<sup>(26)</sup> such as "Happy World" (an importing and retailing group which grew very quickly in the years before the December 1979 devaluation of the Mauritian rupee). Apart from national advertising and competitions, these companies organised their own delivery vans, their own shops and salesmen, price cuts and sales—all the marks of competitive capitalism, a somewhat rare activity in Mauritius. Examples of their style of advertising, indicating the extra services they were prepared to provide their customers are shown in figure 3.21

The only distributors of "Top Board" who did not sell plywood were Harel Mallac, who received distribution rights in return for their shareholding in the Universal Board Co. Consequently, they had a greater interest in promoting "Top Board". Nevertheless they did not greatly modify their warehouse selling methods, rather they continued in the traditional manner of importers, selling the new

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<sup>§</sup> Except, perhaps, the sudden price reduction of plywood on the market the day that "Top Board" appeared, from 48-50 ct/ft<sup>2</sup> to 42 ct/ft<sup>2</sup> (the original thin "Top Board" price)<sup>(6)</sup>, and the price increase following the voluntary liquidation of the Universal Board Co<sup>(8)</sup>.

Figure 3.21a Examples of Mauritian advertisements.

**AGRICULTEURS!  
PLOMBIERS!  
Particuliers!**

Faites entrer le progrès et l'économie dans votre environnement.

Utilisez les TUYAUX EN PVC fabriqués à Maurice par Plastic Pipes and Products Ltd selon les normes internationales qui vous offrent la solution sûre, pratique et économique à tous vos problèmes d'adduction d'eau.

- Mise en place facile et rapide grâce au système sûr et efficace de jonction par collage.
- Absence de corrosion et d'abrasion
- Facilité d'adaptation à votre installation existante grâce à la gamme complète de tuyaux et de raccords allant de 20 mm (1/2") à 200 mm (8").

Pour plus de renseignements consultez les experts:  
**DOGER DE SPÉVILLE & CO. LTD.**

**DDS** Angle des rues Edith Cavell & Mère Barthélémy - Port Louis  
Tel.: 2-2081

↑ Advertisement by a traditional importer in "Week-end", 6 Dec. 1981 —note the absence of special offers or services.

**KING BROS**

**PRIX TOUJOURS IMBATTABLES**

Chaîne stéréo

Cuisinière

Blender avec coffee grinder

Machine à laver

Babyline

Set 6 plateaux inox

Ouvert le dimanche de 9h à midi

**KING BROS**

↑ Advertisement by a Sino-Mauritian company in "Week-end", 20 Dec. 1981 —note the special offers and opening hours.

**JVC TÉLÉVISEURS COULEURS 20"**

La couleur naturelle

**SUPER PROMOTION**

~~Rs 14,640~~  
**Rs 13,185**

Les téléviseurs couleurs JVC sont conçus d'après des normes technologiques internationales les plus avancées.

Ce modèle vous propose des avantages les plus complets: **Tv couleur unique avec deux boutons pour régler les teintes.** Châssis à 100% inoxydable assurant un service durable. **Modèle réglable pour équilibrer tout appareil de Vidéo cassette.** **Contrôle automatique de couleur, luminosité, contraste, etc.**

**SERVICE APRÈS-VENTE GARANTI PAR DES INGÉNIEURS FORMÉS AU JAPON**

**JVC HOUSE**

En location-vente chez:  
Chausse - Port Louis Tel. 4-2172  
Vandermaelen - Fincel Hill Tel. 4-3351  
Sallata - Curepipe - Tel. 6-6601

← Advertisement by the Sino-Mauritian agents of a Japanese company in "Week-end", 14 Feb. 1982 —note the efforts taken to train their staff to provide a better after-sales service.

material like their imported lines. As they did not sell plywood or similar building materials, few people went specially to Harel Mallac to buy "Top Board" when they would have to go elsewhere for many of their other building supplies.

St. Antoine S. E. was not, of course, concerned with the marketing of "Top Board". They had a management contract for the factory, and received rent for the land on which the factory was built. They stood to gain more from this than from possible future dividends on their investment in the Universal Board Co. So their interests lay in keeping the particleboard plant working, but not necessarily investing heavily to make it profitable.

The one group most concerned with the sales of the Universal Board Co. were the management (and staff) of the Universal Board Co. For much of the time it was run by M. Raffray and his secretary, both of whom had other tasks in Harel Mallac Ltd. Raffray was very concerned about the problems of the project. His concerns, mentioned in his PROSI Bulletin interview(5), were also evident in his first interview given to the author in 1976(6). Furthermore, he mentioned in this interview the difficulties the users faced in using the particleboard, and how Dr. Hesch had suggested setting up a school and a furniture factory to help educate the users. He regretted that the company had not made any such effort to educate the consumer, but thought, at that time, that people had become used to the product, were prepared to sharpen their saws more often or buy tungsten carbide tipped saws, and that the users were sticking veneers on to particleboard themselves. He explained how there had been a great market demand for 4 mm plywood (used to make cheap furniture), and the effort they had put in to making 4 mm particle board. They were

eventually successful, although the production capacity was reduced to 8 t/d and even after two seasons there was 25% wastage when producing 4 mm board.

He had received many enquiries from overseas buyers, but the freight always made this uneconomic (and, to a lesser extent, the high overheads on the small plant). Most of these enquiries came from South Africa, with a few from the Seychelles, Comoros, United States, United Kingdom, France, Australia, Bahrein and Kenya. For example, for one potential shipment worth Rs2000/t (f.o.b. Port Louis), the costs of freight to Australia, duty, landing and other charges would have added 78.7% to the price. So the price in store in Australia would have been A\$437/t or A\$6.52/m<sup>2</sup>, more expensive than Australian board at A\$5.77/m<sup>2</sup> or board imported from South Korea at A\$3.23/m<sup>2</sup>(6). Such high freight charges are typical for particle-board, as it is a bulky, low value, product. In general, particle-board is not traded over great distances, but only between neighbouring countries. In 1979, at least 80% by volume of the internationally traded particleboard was between European countries or between the USA and Canada(27).

Consequently, the Universal Board Co. was forced to rely on the local market. But despite Raffray's knowledge of these marketing problems, the Universal Board Co. did little about them. Apart from the initial advertising mentioned before, the company employed a salesman for four months in 1975(8), who was apparently dismissed because the directors thought that the Universal Board Co., already in financial difficulties from losses in previous years, could not afford to pay a salesman for a period long enough to bring results. As Raffray said in his PROSI Bulletin interview:(5)

A l'évidence, il n'était plus possible de mettre sur pied une organisation autonome de "marketing", car la compagnie ne disposait pas de capitaux nécessaires pour se lancer dans une telle entreprise.\*

In this rests the essential explanation of why the Universal Board Co. did so little to improve its marketing. After some years of low sales they had accumulated losses which made some of the directors think more of the company as a failed investment than as a going concern. So to these people any further investment would be a waste of money. The directors were representatives of the major shareholders and creditors, including the Development Bank of Mauritius, the wholesalers, Harel Mallac and St. Antoine S. E. As has been shown previously, many of these had interests outside the company which conflicted with those of the management of the Universal Board Co. As the prices were fixed and the sales policy was discussed by the board of directors(6), and any significant expenditure had to be approved by them, this greatly limited the freedom of action of the manager to improve the marketing.

Before leaving the subject of marketing, the possibilities of sales to users other than small furniture producers must be considered. One successful example of this was the sales to a large furniture factory at Pailles, "Boboulo". This factory changed from producing collapsible furniture from wood to producing furniture from particleboard. They relied on the skills of an Irish manager, Mr. Priscoll, who had had previous experience in Europe in making furniture from particleboard. They veneered the "Top Board" in their own presses using urea-formaldehyde or epoxy glues, and assembled the

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\* It is clear that it was not possible to set up an independent marketing organisation, for the company did not have the necessary capital to start such an enterprise. (Author's translation).

furniture using special plastic hinges or wooden dowels(14). "Top Board" was used in 95% of their production. Furthermore, they acted as an example to other furniture makers who visited Boboulo to learn how to use "Top Board"(6).

One attempt to sell outside the furniture market was less successful. From 1973 to 1977 the Universal Board Co. made tea chests from thin particleboard for one customer. This market increased until the sales of tea chests reached 30% of the total sales (by value) in 1974/75(19). However, this had to be abandoned after the tea chests suffered from declining strength (as mentioned by Hesch, quoted previously), and problems of water absorption in ships' holds, which weakened the boards and occasionally led to changes in the flavour of the tea(8).

The penetration of "Top Board" into the market for building materials was also very limited. Mauritian architects and builders were unfamiliar with the possible applications of particleboard in construction, with how to specify particleboard for particular applications and with the methods of construction needed to achieve these ends. So it is not surprising that the only major contract to supply particleboard for building was placed for government buildings designed by British architects, notably the Registry House in Port Louis. These architects were familiar with the uses of particleboard, so when they heard that particleboard was produced in Mauritius they asked for test samples. On the basis of their test results they specified the thicknesses and densities they required, including 25 mm and 49 mm board which had not previously been produced in Mauritius. This contract greatly increased the sales of the Universal Board Co. (see figure 3.1), but did not lead Mauritian designers to



use "Top Board"—undoubtedly the early reputation of "Top Board" as a poor material which grew fungus still remained in their minds, which reputation, together with a reluctance to learn new techniques, discouraged them.

#### **4. Financial factors**

Raffray has stated that the Universal Board Co. did not have enough capital to set up its own marketing organisation(5), and that it was forced to take credit from the equipment suppliers for want of local capital(6). This suggests that the company was undercapitalised, or at least over-dependent on loans.

The usual equity:capital gearing of Mauritian companies is 1:2, i.e the capital is made up of 1/3 equity and 2/3 loans(26). The Development Bank of Mauritius lends up to 50 or 60% of the equity, so a typical capital formation might be 100 parts equity, 50 parts DBM loan, 75 parts commercial loans (local or foreign), and 75 parts from local banks and creditors. By these standards the Universal Board Co. appeared to be in a favourable position at formation, as shown in figure 3.22, since the shares supplied 37% of the capital. Even without taking up any of their entitlement to a bank overdraft, they had Rs0.8 M available for use as working capital, 50% more than the figure allowed in Ledune's costing of a suggested small-scale particleboard plant design(10). At that time, the only doubts one might have had would have been on the cost of the loans, as the loan provided by the German equipment manufacturers, Siempelkamp GmbH & Co., was in DM at the German bank rate, around 8-10%/a.

In fact, this did turn out to be an expensive loan but not because of the interest rate. The loan was expressed in DM, which in



1970 were worth Rs1.15(6). During the five years before repayment fell due, the Deutsche Mark appreciated against the Mauritian rupee, so that when it had to be repaid the Universal Board Co. had to find Rs2.5 M to convert to the same number of Deutsche Mark which had been worth Rs1.6 M in 1970(5). This loan had been guaranteed by the shareholders of the Universal Board Co., so they loaned the Universal Board Co. money to repay the suppliers credit. These special loans totaled more than the Rs0.9 M currency transaction loss, for the company had not generated the profits to repay the loans:, in fact it had made a loss each year, and the accumulated losses had to be financed by the special loans and by an increasing bank overdraft. These special shareholders loans are detailed in figure 3.23.

Figure 3.22 Universal Board Co. Capital formation and use in selected years.

(kRs)	At start	June 1976	June 1977	June 1978
<u>Financed by:</u>				
Shares	2020	2020	2020	2020
Creditors	-	415	1228	1163
Loans - DBM	1800	1675*	1388	1308
- Siempelkamp	1600	-	-	-
- Bank overdraft	-	1428	1329	1441
- Special loans	-	1431	1668	1434
<u>Total capital</u>	5420†	7094	7633	7366
<u>Employed as:</u>				
Fixed assets	4501	3224	3364	2977
Stocks	9818*	1771	2212	2463
Other cur. assets		376	275	326
Formation expenses	101	101	101	101
Revenue deficit	-	1556	1681	1500

\* By subtraction.

† Assuming no bank overdraft at that time  
Sources Raffray(7) and the accounts(19).

The effect of these changes on the gearing of the company can be

Figure 3.23 Universal Board Co. The shareholders' special loans.

No.	Date	Repayment	Interest	Value /Rs
1st	10/10/73	1983	8%	357 675
2nd	28/2/75	10 installments from 31/1/78	9.5%	} 1 073 692
3rd	15/4/75	ditto	9.5%	
4th	2/9/75	ditto	10%	
5th	14/4/76	ditto	10%	
6th	2/9/76	ditto	10%	271 501

Source: Raffray(8).

seen in figure 3.22. By June 1976 the suppliers credit had been repaid. The level of stocks had risen to 50% of the original fixed capital, much higher than estimates of total working capital used in many project proposals(10,11). Also, a revenue deficit of the same size had built up in five years of operation\*, until, in 1977, the total capital employed was equal to 1.7 times the fixed assets at start-up, financed 1/4 equity : 3/4 creditors + loans. This gearing was within the range found in Mauritius, but was not suitable for industrial investments with a low profit margin. In particular, the interest payments on these loans had a serious effect on the profitability of the venture, as shall shortly be shown.

The amounts of unsold stock were very much higher than had been anticipated. This was a consequence of the marketing difficulties. As selling particleboard in markets where the product is unknown is inevitably difficult, it is likely that any new plant in such an area would have to carry similar stock <sup>levels</sup> until the local users have become used to particleboard.

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\* The fixed costs that had to be paid, despite the low levels of production and sales, had rendered the venture unprofitable.

Higher gearing<sup>†</sup> of a company increases the risks of an enterprise. When the enterprise is profitable, the investors receive higher dividends, as the creditors are satisfied with the same return on their capital. But when losses occur they have to be met from the equity resources of the company, as loans have to be repaid and interest paid whatever the profitability of the company. As marketing problems had not been foreseen when the company was formed, not enough equity capital was sought to protect against initial difficulties in the venture. Indeed, in 1969, the profit level in Mauritian industry, at a time of relatively low sugar prices, was probably not sufficient to generate the large sums for new investment which were later available at the time of the 1974 sugar boom. So, Raffray would have had some difficulty raising more equity capital for a particle-board factory, which would have seemed somewhat risky compared to the sugar industry itself.

Figure 3.24 Universal Board Co. - annual financial costs.

Interest /kRs	1971/72	1976/77	1977/78
Bank overdraft	47	107	137
Siempelkamp	99	0	0
DBM loan int.	27	133	129
DBM guarantee fee	0	10	10
Special loans	0	164	156
Others*	65	3	2
Total	238	417	434

\* Mainly interest to suppliers.

Sources: Raffray(7) and the accounts(19).

The consequences of this high gearing were serious, as can be seen from figure 3.24 which shows the approximate level of the interest payments required to service this debt. Not only did the

<sup>†</sup> Defined on p. 122

interest burden slowly grow, but it was high in terms of the profit made on the low sales, turning potential profits into losses from 1973/74 to 1977/78. The financial costs of Rs434 k in 1977/78 were almost as much as the depreciation (Rs 448 k) in this capital intensive industry, and over 2/3 of the profits before interest payments. To put this in perspective, the earnings and expenditure for 1976/77 and 1977/78 have been summarised in figure 3.25.

Figure 3.25 Universal Board Co. - earnings and expenditure.

(kRs)	1976/77	1977/78
Sales	1401	2851
Cost of sales	1061	2126
(Depreciation)	(253)	(389)
Gross profit	390	738
Admin. expenses	95	122
Selling expenses	3	1
Earnings before interest	292	615
Interest	417	434
Net profit	-125	181

Sources: Raffray(7) and the accounts(19)

A less important, but none the less significant, fixed cost which reduced the profitability of the enterprise can be seen in figure 3.25. This was the cost of administration and selling. It was not discussed earlier with the other fixed costs as it could not possibly be described as a technical factor. So this discussion follows.

#### 4.1. Administration and selling costs.

It is perhaps surprising, that with such difficulties in selling "Top Board", that relatively little was spent on selling the product, as

apart from an initial expenditure, of Rs22 k in 1971/72, on advertising, and Rs 17k on the salary and expenses of a salesman for four months in 1975/76, a mere Rs5 k was spent each year (on average) throughout the life of the company. This was a mere 0.5% of the average cost of sales throughout the same period (Rs981 k)(19).

Figure 3.26 Universal Board Co. - admin. and general expenses

(kRs)	1971/72	1973/74	1976/77	1977/78
Rent	1	24	48	48
Sec. & acct. fees	25	25	25	25
Wages	0	4	7	7
Bad debts	0	0	0	23
Prof. fees and charges	12	11	10	11
Others	3	16	5	8
Total	41	80	95	122

Source: Annual accounts(19).

The administration and general costs were somewhat higher, and rose as rapidly as the other expenses. An approximate summary is given in figure 3.26 The only important costs were those for secretarial and accountancy fees, which were paid to Harel Mallac for the services of Raffray and his secretary, and for rent, which included both the factory and sometimes extra warehouse space in Port Louis. Any savings made here, which could have been used to pay for salesmen and instructional material, could only have benefited the company.

##### 5. Reasons for failure, possibilities of success?

In his interview published in PROSI Bulletin(5), Raffray gave several reasons for the setback of the venture. These were:

- i. Problèmes de mise en route . . . les panneaux aux départ résistaient mal aux conditions climatiques locales et subissaient des attaques de moisissure, . . .\*
- ii. Concurrence soutenue des importateurs qui, de jour au lendemain, ramenèrent le prix de vente traditionnellement pratiqué par eux jusqu'au moment de la commercialisation du produit local.#
- iii. Importation par ces mêmes commerçants (sic) d'un panneau en contre-plaqué de 3 mm d'épaisseur des pays d'Asie, jusque-là inconnu sur lem (sic) arché local.†
- iv. Dévaluation de la roupie par rapport au deutsche mark allemand, . . .§
- v. Augmentations spectaculaires et certainement imprévisibles des coûts de production . . .‡
- vi. Saint-Antoine au coût de Rs70 la tonne . . . et payer son électricité à 70 cs de moyenne l'unité, alors qu'à l'étude du projet la bagasse était gratuite et l'électricité à 4 cs l'unité.⊕
- vii. La commercialisation des produits de l'usine avait été, à tort ou à raison, confiée aux importateurs. La promotion locale laissa certainement à désirer. Par ailleurs, en raison surtout du coût élevé du fret nous n'étions pas compétitifs sur les marchés extérieurs.\*\*
- viii. Une condition essentielle pour la survie de la compagnie . . . il fallait contrôler l'importation dans une certaine mesure, . . . afin de s'assurer que la part de l'usine locale ne soit pas inférieure à 1 500 tonnes.

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\* Start-up problems . . . at first the boards did not stand up well to the local climate and went mouldy, . . .

# Sustained competition by importers who lowered overnight the selling price (of plywood) at which they had traditionally sold up to the moment that the local product was commercialized.

† Imports, by these same merchants, of 3 mm Asian plywood, up to then unknown on the local market.

§ Devaluation of the Rupee against the Deutsche Mark, . . .

‡ Spectacular and certainly unforeseeable production cost increases . . .

⊕ . . . the company had to be supplied from outside St. Antoine at a cost of Rs70/t . . . and pay on average 70 ct/unit for its electricity, although in the project study bagasse was free and the electricity was costed at 4 ct/unit.

\*\* The marketing of the factory products was, for better or worse, entrusted to the importers (of plywood). Certainly, the local promotion left a lot to be desired. On the other hand, because of high freight costs we were not competitive in overseas markets.

Quatre requêtes successives dans ce sens furent adressées au ministère des Finances, au ministère du Commerce et de l'Industrie et au ministère du Plan et du Développement. . . . les ministères concernés faisaient la sourde oreille . . . ##

Raffray did not attempt to assess the relative importance of these problems, excepting his conclusion that: " je pense sincèrement que l'entreprise aurait survécu si, d'une part, le 'marketing' avait été mieux organisé et si, d'autre part, un effort avait été entrepris par le gouvernement pour contrôler les importations, . . . " <sup>⊕</sup> As an aid to assessment of the importance of the causes of failure, and under what conditions the company might have prospered, a sensitivity analysis has been carried out on the results for 1977/78, the company's most profitable year (in which it was supplying a special order of particleboard for the Registry House). This analysis is presented in figure 3.27. The different reasons <sup>for failure</sup> will be considered in turn.

i. Start-up problems, especially fungal attack.

The growth of mould was not a serious technical problem, and it was solved by the application of an expensive fungicide. Although Raffray(5) claimed that this left "Top Board" with a bad reputation, this can hardly explain low sales throughout so many years, as the fungal growth problem was solved within the first two years. If such

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## An essential condition for the survival of the company . . . it was necessary to control imports to a certain extent, . . . in order to ensure that the local factory's part (of the market) was not less than 1500 t. Four successive requests were made to the Ministry of Finance, the Ministry of Commerce and Industry and the Ministry of Economic Planning and Development. <sup>⊕</sup> . . . I sincerely think that the enterprise would have survived if, on the one hand, the marketing had been better organised and if, on the other hand, the government had made an effort to control imports,



Figure 3.27 UBC - sensitivity analysis on 1977/78 results.

(kRs/a)	A	B	C	D	E
Sales income	2864	2864	3150	2864	1312
Cost of sales	2126	1867	2126	2048	804
(Depreciation)	(389)	(389)	(389)	(311)	(389)
(Fixed costs)	(361)	(361)	(361)	(361)	}(415)
(Var. costs)	(1376)	(1117)	(1376)	(1376)	
Admin. costs	132	132	132	132	80
Selling costs	1	1	1	1	1
Financial costs	424	424	424	334	424
Profit	181	440	467	349	3
	F	G	H	I	J
Sales income	2864	2864	2864	5728	1432
Cost of sales	1965	2046	1883	3502	1438
(Depreciation)	(389)	(389)	(389)	(389)	(389)
(Fixed costs)	(200)	(361)	(361)	(361)	(361)
(Var. costs)	(1376)	(1296)	(1133)	(2752)	(688)
Admin. costs	108	132	132	132	132
Selling costs	1	1	1	60	0
Financial costs	424	424	424	424	424
Profit	366	261	424	1600	-562

( ) - Breakdown of figure above, ∴ not added into total

A - Base, 1977/78.

B - Without any fungicide.

C - +10% on the selling price.

D - Without any currency transaction loss on the DM loan.

E - Unit production costs and selling prices at 1973/74 levels.

F - 1/2 x (Management fee + rent).

G - With free bagasse.

H - Electricity at 4 ct/kWh

I - Sales x 2

J - Sales x 1/2

Examples of the calculations are given in appendix 3. The base figures are taken from the accounts(19).

a reputation did exist, it could have been countered by specific publicity to show (by demonstrations or money-back guarantees) that "Top Board" suffered no more from fungal attack at high humidities than ordinary grades of plywood or timber. Furthermore, such a reputation would not affect the sales of "Top Board" to the drier parts of the island, outside the central plateau.

The solution to this problem did, however, increase the production cost, as shown in figure 3.27. If no fungicides had been used, the profits for 1977/78 would have been Rs440 k instead of Rs181 k—but without fungicide they would have sold less, and made a loss. The problem of fungal growth, under conditions of high humidity, should have been foreseen when the project proposals were made, as it is a common problem in the humid tropics, especially for bagasse-based board, containing residual sugars. It is, however, often ignored in general case studies(10,11), but should have been mentioned by Verkor S. A., Siempelkamp GmbH, or by Dr.Hesch when Raffray was planning the plant.

ii. Price competition by the plywood importers.

When "Top Board" appeared on the Mauritian market they dropped their prices for the thinnest plywood by 20%(6). As the particleboard project had been costed assuming that the selling prices of plywood would remain constant, this reduced the margin between the particleboard and plywood prices which might have encouraged users to change to particleboard, and also prevented the "Top Board" price being increased to fully match production cost increases. No attempt had been made to estimate the price of plywood to the wholesalers, by making use of the Customs and Excise import statistics and the rates of duty payable. If particleboard cannot be produced at below the import cost of plywood, its production is doomed, since particleboard has to be sold at a substantial discount to compensate for the difficulties of use compared to plywood. According to Pleydell, who was involved in setting up the UAC of Nigeria Ltd., particleboard plant at Sapele, Nigeria, this discount usually has to be at least 30%(28).

iii The import of 3 mm board

There were some potential users of particleboard in Mauritius to whom any discount, however small, was worth taking, as they were trying to produce furniture as cheaply as possible with no thought to the quality of their product. They used 4 mm plywood until the Universal Board Co. succeeded in producing 4 mm particleboard, whereupon they switched to 4 mm particleboard. This was achieved at great cost to the company, as the pressing of 4 mm board reduced the production rate from 15 t/d to 8 t/d and the wastage rate increased, being 25% on this type of board in 1973(6). After the Universal Board Co. had gone to these lengths to capture this market, the plywood importers started to import 3 mm Asian plywood, which undercut the price of the 4 mm particleboard. Despite being a poor quality plywood, it still took away this market from particleboard. This was only serious because the usage of boards in Mauritius was different from that in Europe, a greater proportion being thinner board used for furniture.

iv . Devaluation of the Mauritian Rupee against the Deutsche Mark.

This converted what would have been a cheap loan at 5.5%/a interest, lower than the inflation rate of 9.5%/a over the same period, to an expensive one at 14%/a internal rate of return.\* This converted a possible financial gain (if the equipment appreciated at the general rate of inflation) into a financial loss. Nevertheless, as can be seen from figure 3.27, this had a relatively small effect on the profitability as compared with the sales volume, selling price

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\* To the lender, but calculated in Mauritian rupees, as the rate required to discount the total repayments of Rs2.5 M at the end(5) plus the annual interest payments given in the accounts(19) (of Rs60 k, 99 k, 111 k, 97 k, and 69 k in successive years), to produce a present value equal to the amount of the loan (Rs1.6 M(5)). The Mauritian cost-of-living index rose by 58% in the same period (1970-5)(24).

or the accumulated revenue deficits. (Rs1.7 M in June 1977: see figure 3.22).

v. Spectacular production cost increases.

As can be seen from column E of figure 3.27 the profit would actually have been less if the production costs and selling prices had remained at 1973/74 levels, undoubtedly because of the high cost of fixed charges at the low production volumes. Some of Raffray's quoted spectacular increases referred to items which only made up a small proportion of the production cost, such as insurance (2.5%) or fuel oil (8.2%).

However, these costs grew at a higher rate than the general rate of inflation and the growth in plywood import prices (see figure 3.21). As the selling prices were limited by competition with plywood, this process was in the long term squeezing the profit margins. But more important, in terms of the cost structure of the company, was the increase in the fixed costs, as they greatly affected the profitability at such low sales levels.

For this reason column F of figure 3.27 was calculated, to show the effect of reducing two of the fixed costs, the management fee and the rent. Again this would have resulted in a small, but reasonable, improvement in the profitability of the Universal Board Co. (but at the expense of the St. Antoine S. E., illustrating a conflict of interest on the part of this shareholder).

vi. The costs of bagasse and electricity.

One can only wonder at the assumptions made in the original costings. Even baled bagasse from St. Antoine for use outside the

crushing season has a cost, as shown by Lam(12). In any case, the bagasse cost is only a small proportion of the total costs, and the use of free bagasse would only have increased the profits by 3% of turnover (See figure 3.27).

Raffray claimed, in an interview(8), that the bagasse and electricity prices had been in the contract with the St. Antoine S. E. Co., which should have supplied the bagasse and steam for conversion to electricity, but for reasons of force majeure the contract had to be revoked. In the case of bagasse this was understandable, as the bagasse surplus at St. Antoine declined, and was not enough to supply the particleboard plant. This is not so clear in the case of electricity, unless the agreement came up against the Mauritian law that it is illegal for any company to sell electricity to another. Only the Central Electricity Board is permitted to sell electricity. The Universal Board Co. Ltd. was set up as a Development Certificate company (for the tax advantages and access to Development Bank of Mauritius loans), separate from St. Antoine S. E. As separate companies, St. Antoine could not sell electricity to the Universal Board Co. It seems that when the project study was made the law had been insufficiently studied, and it had been mistakenly assumed that the Universal Board Co. could buy electricity from St. Antoine. The idea of St. Antoine lending the Universal Board Co. a small turbo-alternator and supplying live steam to power this generator was described as a new idea, in 1976, by Raffray during an interview(6) and so it does not seem likely that this was in the original contract.

In any case, the average electricity cost could not have been Rs0.04/kWh, as the factory would have had to buy electricity from the CEB outside the crushing season, when <sup>the</sup> St. Antoine sugar factory was

shut down. Under these conditions the company would have to pay a minimum demand charge whether or not it was using electricity from the CEB. It seems also unlikely that, even if permitted by law, the sugar factory would have sold electricity for less than it would have received from the CEB for sales of electricity to the grid. In 1976 the sugar factories received around Rs0.10/kWh for their electricity sales to the CEB.

In figure 3.27 has been calculated the profitability of the company, if the factory had been able to buy all its electricity at Rs0.04/kWh and pay no demand charge. Even in these (very unlikely) conditions the profitability would have been raised only to Rs424 k/a, a moderate increase.

vii. The selling of the product being given to the importers, and the inadequate local promotion.

Marketing was indeed the key to the success or failure of the venture, as columns I and J of figure 3.27 show. The profitability was most sensitive to changes in the sales volume. Although Raffray understood these marketing difficulties (as explained during interview with the author), he, perhaps, did not take them very seriously, as there is no mention of user education in his PROSI interview(5). Or, perhaps, the reason given in this article reflects the process by which suggestions for improving the marketing were rejected: suggestions such as the German government offer of a carpenter to train Mauritian carpenters how to apply particleboard(18), and the continuation of the employment of a salesman after only four months work. As already discussed in the section on marketing, it was not in the interests of the wholesalers to promote "Top Board" strenuously,

nor was it within their experience to provide any more than minimal services to the consumer.

Raffray claims, in the PROSI article(5), that the company did not have the capital to set up an independent marketing organisation, but, at one point, the Universal Board Co. had to hire a warehouse to store unsold "Top Board" as there was no more space in the factory or the wholesalers warehouses. This money would have been better invested in marketing the board, especially as the wholesalers made no effort to market the product, apart from giving space in their warehouses. A more likely explanation is that, as Harel Mallac Ltd. did not have sufficient profits in 1969 to generate large amounts of investment capital when expanding in shipping, aviation and the fertilizer factory, they had little to spare for ventures such as particleboard production. Therefore, they needed the capital from the wholesalers. At that time, there was not the liquidity in the sugar industry which existed after the 1974 boom in sugar prices (when they could raise Rs20-30 M at short notice when Mauritius Commercial Fertiliser Industries were in difficulties the end of 1975).

viii. The refusal by the government to restrict plywood imports.

Although approached in November 1973, March 1976, December 1977 and June 1978, the government did nothing until the customs duties on imported boards were raised, in July 1979, after the directors of the Universal Board Co. had decided on the liquidation of the company. It is clear that guaranteed sales of 1500 t/a would have ensured the profitability of the plant—Rs1.6 M according to figure 3.27, enough to remove the revenue deficit in one year. This would have only restricted a part of the market, as the imports of plywood were running



at 3000 t/a(5) or nearly  $1.2 \times 10^6 \text{ m}^2$  (see figure 3.20) in 1977.

The government attitude could have been influenced by the figures shown in figure 3.20; the sales of "Top Board" were only a tiny part of the total market, despite an increasing demand which should have favoured the penetration of new products. Thus, it was clear to them that the company was not trying and, after five years, was asking the government to bail them out. As none of the people involved were related to Ministers, the officials saw no reason why they should help—after all the sugar industry, traditionally, looked after its own. The increase, in the 1979/80 budget, of the customs dues on boards can be seen as an attempt to restrict demand, and so improve the balance of payments, <sup>rather</sup> than as an attempt to protect the particleboard plant. Note that the particleboard has a high import content, as the greater part of the raw materials are imported; such as the resins and fungicides, and many other inputs are highly import dependent, such as electricity (see figure 3.14). Nor could the plant be justified in terms of employment policy, as it only employed 36 workers(5). The other factories which had import protection (e.g. razor blades and dry cell production) had negotiated this protection before starting production, not two years later.

So, at last, a more balanced assessment can be made of this failure. The prime problem was a marketing one. The factory did not sell enough to cover the high fixed costs in a fairly capital-intensive industry (Rs0.2 M/employee, about US\$30 k/employee). All the other reasons must be seen as subsidiary attempts to explain why certain marketing options were restricted. The production costs were important, in that they prevented the company from offering a substan-

tial discount on the plywood prices. The absence of government import restrictions and the import of cheap plywood prevented the "Top Board" price being raised, temporarily, to cover costs at low production levels. And the wholesalers' conflict of interest, between their importing operations and their shareholding in the Universal Board Co., restricted the possibilities of better sales promotion and user education, as there was no strong central management to overrule them on the Board of Directors. But, the fundamental problems were in user education and producing the right quality of board for each use.

## 6. Conclusions from the "Top Board" saga.

In his interview in PROSI Bulletin, Raffray states:

je pense sincèrement que l'entreprise aurait survécu si, d'une part, le 'marketing' avait été mieux organisé et si, d'autre part, un effort avait été entrepris par le gouvernement pour contrôler les importations, . . . \*

I agree. However, it is one thing to wish this and another to achieve it. It is not our ideals which determine the success of the introduction of a new technology but the material conditions which determine the ways in which the technology interacts with a particular society.

To understand <sup>fully</sup> what happened neither the technologist's nor the economist's conceptions of "technology" suffice. The technical problems were minor and the product quality was such that, in Europe, it would have been used for cheap furniture and other less demanding uses. Nor does the idea of technology as a production method we can choose to produce a certain product help - indeed we could consider particleboard in Europe (where people know how to use it) and particleboard in Mauritius as different products, thus re-emphasising the

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\* Translated on page 129

role of the social interactions of this solid object.

If, at a superficial level, the problem of the Universal Board Co. was that they could not sell enough; to understand this it is necessary to understand the buyers and the sellers as humans with interests and norms (e.g. how to make furniture), playing out their roles in the drama of "Top Board".

In Europe particleboard is an established material, used in factories where the managers and workers know how to use it, and where particleboard, fibreboard, plywood or timber is chosen according to the combination of properties and price required in the finished article. The technology of particleboard is not simply the production of the board but, also the knowledge of how and when to use it in a social context of long-established relationships between customer and producer, one-to-one (special boards to order, helping the users change their production process when changing to your board from some other type) or generalised through standards and trade associations.

To introduce particleboard successfully <sup>carefully</sup> into Mauritius, it was necessary to introduce not only the product but also to establish a set of social relationships, which could carry out the functions of such a producer-consumer network and be able to introduce the basic technology of use.

The only close relationship between the Universal Board Co. and one of its consumers was with the Boboulo furniture factory. As Boboulo had a manager who knew how to make furniture from particleboard, this was a straightforward relationship. Priscoll's only complaint being of the unevenness of the boards, as they had been assured

that Boboulo would not need a thicknesser, as the boards would be of even thickness, only a sander. At one point there was even talk of Boboulo taking over or investing in the Universal Board Co.

A similar close relationship was established between the architects of the Registry House in Port Louis and the Universal Board Co. In this case, not only was the technology of use supplied by the architects, but they intervened in the production by testing the boards and specifying according to the results of their tests, requesting special 49 mm board which the factory had not previously produced. The board was used for internal partitioning and cladding.

In complete contrast to this, the other Mauritian users, mainly small furniture workshops producing cheap furniture (high quality furniture was and continues to be made of good timber), were not part of the culture of particleboard, did not know how to assemble furniture made with particleboard, did not know how to make use of the strength of the thicker board (cheaper than thick plywood) to reduce the amount of wood framing, <sup>not</sup> how to veneer the board (not only for appearance but also to reduce moisture penetration and reduce abrasive wear).

As far as the Universal Board Co. were concerned, the role of the users was a passive one, merely to buy the product. The "market survey" made before start-up considered only the total demand for board products, not the specific needs of each user. Contrast the market survey of local bakers carried out by Yeast Producers (Mtius) Ltd. and described in the chapter on this factory. The people who carried out this survey visited every baker on the island and found out how much yeast each baker used, and what they thought of the

locally produced yeast, so that the factory could change the process to produce yeast of the characteristics desired by the users. The users of "Top Board" did not even take on the passive role expected of them by the Universal Board Co. Some of them became even more passive and became non-buyers (they did not even try the board, or tried it once only), while another small group took an active role to find out for themselves how to use the board (by trial and error, or by visiting Boboulo). Some of this group went as far as veneering their own boards(6), although some of the boards seen by the author had only been veneered on their faces and left open, at the edges, to the effects of moisture, which suggests a more rudimentary approach than that of Boboulo. Some of this group bought tungsten carbide tipped blades, for circular saws, to ease the cutting of the bagasse board(6) together with a smaller improvement in cutting timber.

This group of users was small, probably because the price saving on plywood was not enough to encourage less adventurous souls to try and use "Top Board" without any guidance from the manufacturers. This small group of users seems to have declined after 1976 to judge from the sales figures (see figure 3.1). In 1976, <sup>?</sup> occurred the maximum c.i.f. plywood price between 1970 and 1977.

In the circumstances, one might have expected the groups involved in the Universal Board Co., to have acted in order to reach the users, show them how to use the board, and support them with publicity campaigns extolling the virtues of the new, fungus-proof "Top Board". In other words, to try to establish a social-technological system on the island in which particleboard would have a place. That they did not do this implies that either they did not analyse the lack of sales in these terms, or that their own conflicting interests prevented them

from taking any concrete action.

Certainly Raffray was aware of the situation. He had been advised by Hesch at the beginning that they would need to set up their own school and furniture plant, as he mentioned during an interview in 1976(6). He did not, however, mention this in his PROSI interview(5), suggesting that he considered the users' difficulties as one of many problems. He seems to have thought, in 1976, that the users had come to learn how to use the particleboard in spite of the lack of support from the factory(6).

It is difficult to know whether the other main groups involved, St. Antoine S. E. and the wholesalers, thought there was a problem of poor marketing rather than just one of low sales. St. Antoine S. E. was obviously more concerned with production, as it had the management contract for the factory. Certainly, Lam's study did not relate why he considered a reduced level of production of 1250 t/a, but instead concentrated on the production costs, talking about savings through control of resin wastage and labour costs when far greater savings could have been made by increasing the sales and production. St. Antoine S. E.'s concern for the interests of the Universal Board Co. was shown by the doubling of the management contract fee between 1974/75 and 1975/76.

It seems unlikely that the wholesalers even considered how the buyers of "Top Board might use it. This is not a problem when importing well known products, so their organisations were not adapted to provide applications advice, apart from distributing manufacturers leaflets when they had any. Their marketing was writing letters or waiting for people to come to them. Rather more important to the suc-

cess of the large importing companies was their ability, through family and communal ties, to restrict the number of authorised importers of any given product to a select few who then agreed to share the market at an agreed price. For example, when "Lucozade" was imported by a Sino-Mauritian company, Scott & Co. took over the agency and then tried to force out this family company, claiming that competition would lead to unstable prices. Nevertheless, this family concern stayed in the market on a 2% margin, and provided sufficiently difficult competition for Scott & Co. that the Scott representative resigned from this department(26).

Even if the wholesalers had realised the social aspects of the marketing problem, they had an obvious conflict of interest in that they sold both "Top Board" and plywood. With an unrestricted market and fairly close selling prices, a sale of "Top Board" represented a lost plywood sale ("Top Board was not sufficiently cheap that it could have opened new low price markets, nor of sufficiently high quality to take away high price markets from timber). Consequently, their interest in selling "Top Board" depended on the relative profit margins on plywood and "Top Board". As it appears that they made more profit on plywood, they left all advertising to the Universal Board Co.

This lack of commitment to the company on the part of the St. Antoine S. E. and the wholesalers resulted from the fact that they got their income independently of the financial state of the Universal Board Co. While the company was losing Rs200 k/a, St. Antoine was receiving about Rs 350k/a in management fees, and the wholesalers some Rs180 k in 1975/76 on "Top Board" (at 18.5% margin) and more on their imports of plywood. When the Universal Board Co. went into



liquidation the wholesalers immediately raised their plywood prices(8), thus increasing their profits even more.

In this light can be understood some decisions which otherwise seem to make little sense. In 1975, a salesman was appointed for four months at Rs2000/month. Together with travelling expenses, this cost the company Rs4000-5000 monthly, a very small sum in comparison with the possible gains if he could have increased the sales. After four months he was dismissed. There had been no upward trend in sales over this time, but this was to be expected as he had to gain the trust of potential users over a long period of time, by showing them how they could use "Top Board" in their products, how they could joint the boards, how to redesign their products to make use of the advantages and avoid the disadvantages of particleboard. This is a long term process which would have required many repeat visits. Considering the sales problems of the company at the time this cannot, with hindsight, be said to have been a logical decision. It can only be understood in terms of the conflicts of interests between the different groups represented on the board of directors of the Universal Board Co., and the idea that many of them were most interested in minimising their risks. The wholesalers and sugar factory had invested little in the company compared to the income they were receiving from their other operations and, when the Universal Board Co. was in difficulties, they were more concerned that they did not throw away this money on "unnecessary extras", like salesmen, than on the possibilities of turning round the company with extra investment. Their vision was of what they would get upon the liquidation of the company rather than what they might get if it were a success. This should be contrasted with the actions of the directors of Floreal

Knitwear when that company was in difficulties. They brought in a marketing specialist who restored the fortunes of the company by finding new markets(26).

In a similar light can be seen the arrangement by which the guarantees given by the shareholders to Siempelkamp, when called in, were considered as loans rather than an increase in the equity, so that if the company folded they would receive preferential treatment over the other shareholders. Thus they minimised their risks at the expense of increasing the burden of interest payments on the Universal Board Co.

So we see that neither the social relationships between buyer and seller, nor those between the shareholders were appropriate to the introduction of the complete technology of particleboard production and use. The actors behaved according to their Mauritian norms, not perceiving this as an obstacle to the implantation of the technology which had been transferred to the island out of a different social context. The users had to be taught how to use the product, and the shareholders how to run an industrial (rather than commercial), local (rather than export) venture, and how to market a new product. As only the production technology was transferred to Mauritius by the Universal Board Co., the only successful applications of the product were when the rest of the technological system was imported by others in the shape of Mr. Priscoll, at Boboulo, or the British architects, for the Registry House.

It was the incompatibility of the technology, as introduced, and the Mauritian social context which led to the inevitable failure. Only if the introduction of particleboard had been considered in

terms of introducing a complete technological/social system might such a venture have succeeded. Such an approach would have been very different, involving, in Mauritius, at least some of the following:

- i. A proper market survey at the start, interviewing users of imported board to get an idea of the problems they might have and supplying samples of imported particleboard for them to try. This survey could also have determined what thicknesses of board were in demand, and the environmental conditions in which the boards were kept and the finished articles used.
- ii. Contacts with an existing furniture factory that might be interested in using particleboard so that the board producers could supply information on methods of assembly, and the furniture factory could act as a demonstration plant for the others.
- iii. Contacts with technical training institutions to see if they could include particleboard use in their carpentry courses, and arrange special courses in particleboard use for existing carpenters (funded by the particleboard factory).
- iv. When preparing the feasibility study, look at the advantages of integration of the plant with a sugar factory; not only in terms of bagasse supply, but also as a source of electricity, and steam and flue gases for preheating the air used in the bagasse driers. As a low demand can be expected during the first few years of operation, there would be no need to produce outside the crushing season, and, hence, no need to be connected to the CEB supply. This might require, in some places, that the particleboard plant is run directly by the sugar factory as part of the factory company, so the tax concessions for new industries under

schemes such as the Mauritian Development Certificate would not be available. On the other hand the losses of the particleboard factory in the first few years, until a market is established, could be set against sugar manufacturing profits to reduce the taxation of the sugar factory (there is no point having a tax holiday if your company is making a loss).

- v. Finding a design of plant which starts very small and can be expanded later. At present such designs of small plants to supply small countries do not exist, as even the studies in the FAO portfolio of small scale particleboard plants propose minimum size plants of 3640t/a of 19 mm board(10) or 25 m<sup>3</sup>/day of 19 mm board(11). These are small-scale plants for larger countries than Mauritius.
- vi. Negotiate before start-up, with the government, for import controls or duties for a defined short-term period starting from the day the factory produces a product which meets agreed standards. (This would be more acceptable to governments than asking for permanent import restrictions after the factory has already started production.)
- vii. Arranging for all the publicity to have an educational content. Not only the carpenters have to know how to use the boards.\*

Finally, to return to my initial assertion, that this was an "appropriate technology" that failed. In a technical sense particle-

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\* For example, architects. When the Minister of Public works in Moçambique told a meeting of local architects that they had to design more buildings in locally produced brick rather than cement with a 50% import content, nothing happened—the architects did not know how to design brick buildings.

board production remains an appropriate technology for producing boards in a region where there are few trees but a lot of bagasse. Even with imported resin it saves on foreign exchange; it has possibilities of integration with existing industries (not realised in this case); makes use of renewable resources; produces little pollution and uses little water (unlike fibreboard production); can create employment (depending on the design - the Verkor design needs 141 people(10)); and reduces import dependence in the basic need of housing materials. It could be said that the type of factory was not the most appropriate, being mechanised, not integrated with the sugar factory and at a capacity above the total market in 1969. Given the lack of alternative designs at the time, and the lack of a Mauritian capacity to design a smaller particleboard plant, the only practical alternative would have been a small-scale fibreboard plant as proposed by the Indian Government Techno-Economic Mission to Mauritius(20), similar to those in existence in India and Sri Lanka(29) and plants in Madagascar and Kenya(30). Apart from technical problems with bagasse fibreboard plants, in terms of the production of weak boards, water use and pollution, the basic problem remains the same—both boards have to be handled by special techniques, unnecessary with timber or plywood.

So it is not the technical appropriateness of this transfer of technology which can be called into question but its social appropriateness. Here the term "technology" is used to refer not just to the production process, but also the applications of the board, methods of use, marketing methods, training programmes, and the social relationships between the using and producing groups—i.e. the complete technological/social network within which particleboard can be pro-

duced and used. This technology is not fixed in time but develops, as people learn how to use the material, invent new applications, as the factory responds to the needs of users by producing boards of special quality, or thickness or treatment — a historical process of the implantation of a technology, of the creation of institutions and social relationships within Mauritian society which could permit the efficient use and, therefore, production of particleboard.

Why should one wish to choose or design an appropriate technology? One reason is to apply it in some place where such a technology has not been available before. When so applied, the process of implementation is critically important, and it is in this historical process of technology interacting with society that we can locate the social appropriateness of a technology, not in a list of "ideal" characteristics.

When I claim that this transfer of particleboard production technology to Mauritius was socially inappropriate, it is because only a part of the technology was transferred. The production but not the use. The product outwith its social context. It could only have been appropriate in the context of training schools, demonstration factories, import controls, and two way communication between the users and the producers. Such a set of social institutions were not introduced with the factory.

It is only by considering these interactions between a society and the social requirements of a technology as a historical process

that socially appropriate technologies can be identified and applied.

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## CHAPTER FOUR

### The dried yeast factory - an inappropriate technology in Mauritius.

Of the traditional industries based on molasses only one, cane spirit production, had continued into modern times in Mauritius. While Mauritian molasses might be used elsewhere for yeast production, no yeast was produced in the island in the early 1970s. The many bakers on the island depended on imported yeast and re-use of old dough.

In August 1975, a factory alongside Deep River - Beau Champ sugar factory started producing active dried bakers' yeast for export and local sales. This factory, Yeast Producers (Mauritius) Ltd., ceased production in April 1978.

This chapter is the story of the rise and fall of this high-technology yeast factory in the third world. In it is described the history of the plant, the production process, the problems the company faced, and their relative contribution to the final failure. The roles of the process of technology transfer, foreign competition, exporting from a 'sea-locked' island and social interaction in Mauritian companies will be indicated, but full discussion will be saved for a later chapter.

#### **1. History**

In the early 1970s the Anchor Yeast Co. of South Africa started looking for overseas sites for expansion, as the profitability of further plants was limited by the costs of transporting either molasses or dried yeast over large distances from the sugar producing areas to the cities, where most of the yeast was consumed. As

Mauritius exports large quantities of molasses, and has a local market very close to the sugar factories, they went to Mauritius in search of a partner with whom to collaborate in the setting up of a dried yeast plant.\*

They had preliminary discussions with the managements of several sugar estates and, eventually, came to an agreement with Deep River - Beau Champ Sugar Estate to establish Yeast Producers (Mtius) Ltd., with 51% Mauritian capital (Deep River - Beau Champ S. E.) and 49% South African (Anchor Yeast). This company would set up a 1000 t/a (nominal) capacity dried yeast plant costing about six million rupees. As the local market had been estimated at 80 t/a (#), this meant that they would have to export over 90% of production. The export marketing was left to the Mauritian company, as the South African Company had experience only of covert sales to neighbouring African countries.

Only one and a half million rupees of shares were taken up, the rest of the capital was raised as medium term loans and shareholders loans. By 31 December 1977, these loans had risen to a one million rupee shareholders loan and Rs5.2 M of medium term loans (Anglo-Mauritius Assurance Society Ltd. - Rs2 M, Mauritius Commercial Bank Finance Corporation - Rs1.8 M, Deep River - Beau Champ Ltd. - Rs1.4 M)(3). So the initial gearing was at least 4 : 1, partly as a result of the South African company not taking up the shares to which

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\* All information in this chapter not otherwise referenced has been taken from interviews of M. Serge Duvergé, the former production manager of Yeast Producers (Mtius) Ltd., in August 1976, November 1976, January 1980 and July 1981.

# In fact, the yeast imports in 1976 and 1977 were 42 870 kg and 45 424 kg respectively(1), while the sales of domestic production were only 18 t for the financial year 1976/77(2), making a total local market of only 62 t.

it was entitled under the agreement.

This Mauritian capital was used to erect a building to house the plant, pay for locally welded stainless steel fermentation vessels and tanks (using plans provided by Anchor Yeast), and import process equipment such as heat exchangers and centrifuges from South Africa (including equipment not manufactured in South Africa). The plant erection was supervised by three South African consultants.

Yeast Producers (Mtius) Ltd. sent an agronomist, then working as a sugar factory chemist at Beau Champ S.E., on a five month course in South Africa to be trained as production manager for the new factory. This agronomist, M. Serge Duvergé, had had no previous training in industrial microbiology, but, nevertheless, was chosen for the post even though there were Mauritian microbiologists on the island working in jobs unrelated to their training.

Thus the company was completely dependent on the South Africans for their technology. They had no independent expertise on the Mauritian side, nor had Beau Champ S.E. made any substantial effort to consult other Mauritian bodies such as the University or MSIRI. Because of this they had to accept, at face value, the assurances of Anchor Yeast concerning their technology - no critical evaluation was possible. There was no way of checking Anchor Yeast's production costing of Rs3.25/kg. Also, the managers and workers did not have the fundamental knowledge of the process needed to adapt it when necessary (as was made clear later when they did adapt the process, but only under the guidance of engineers from another foreign company). Anchor Yeast had not bothered to transfer this part of the technology, and the Beau Champ S.E. managers had not realised that

this was needed.

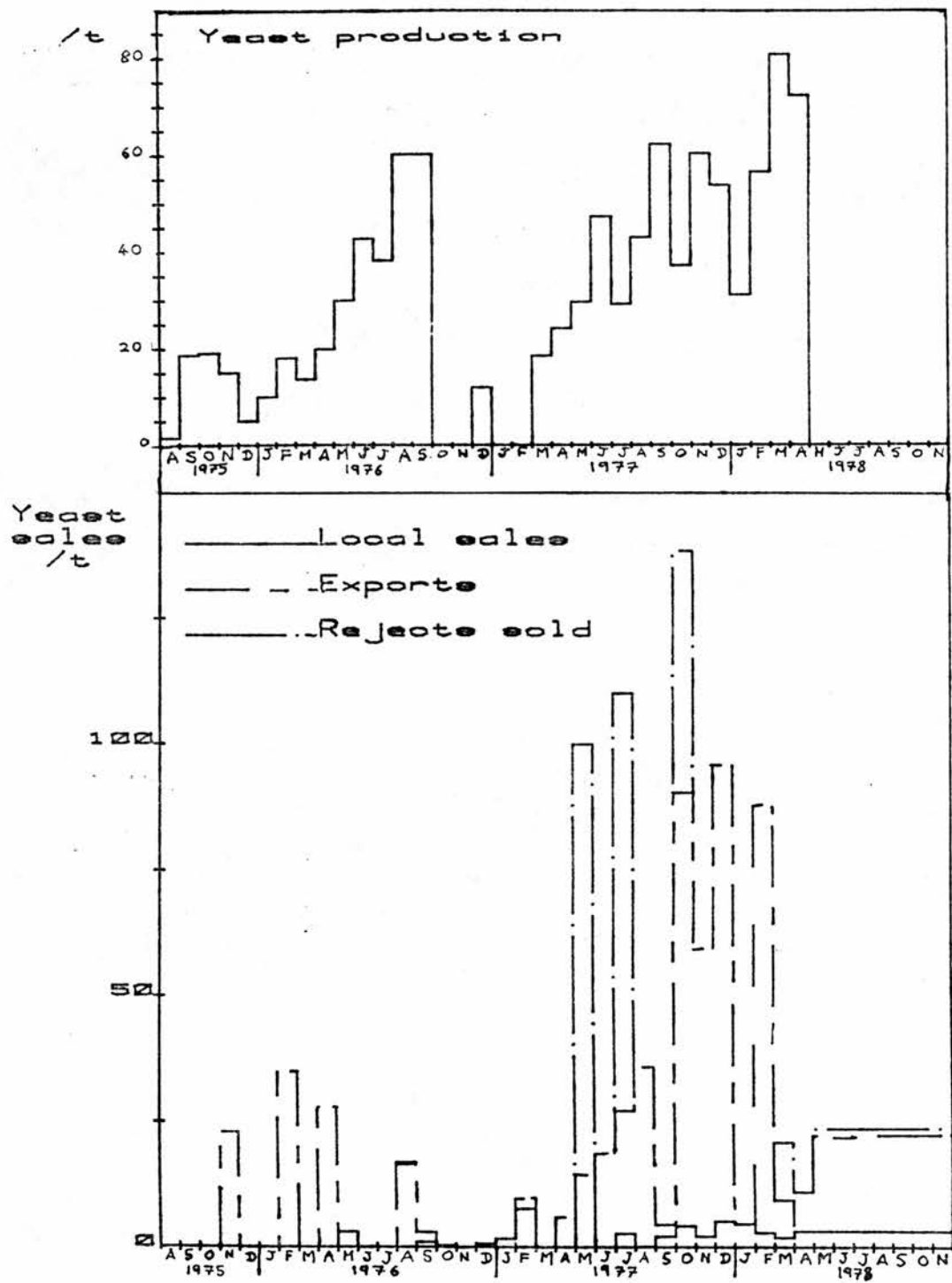
So, on the insecure foundations of limited technical knowledge and a 4:1 geared company, Yeast Producers (Mtius) Ltd. set out to conquer world markets.

They started production in a small way in August 1975, by producing small quantities for samples while the staff learned how to manage the factory. In December 1975, they learned one lesson the hard way. They had a bad wild yeast infection which reduced their production from fifteen tonnes to five. The source of the infection was traced to the air filter, or rather, to the absence of one. The South African engineers had assumed that as the factory was in the countryside there would be little pollution, and no filter would be needed. In fact, the sugarcane fields provide a vast reservoir of wild yeasts growing on the stems. So an air filter had to be installed.

Apart from this, the factory managed to produce reasonable quantities of yeast. What proved more difficult was to sell it. Figure 4.1 shows the factory's production and sales throughout its life. From this we see that for the first year and a half Yeast Producers (Mtius) Ltd. sold very little yeast, about 100 t out of about 350 t produced.

The man then responsible for export sales was M. Hugnin, who was also manager of Mauritius Breweries Ltd., Gaz Carbonique and the Coca Cola factory. Thus his yeast marketing was very much a sideline activity. He did not have the time to visit prospective overseas buyers, nor did Yeast Producers (Mtius) have the cash to pay for this, so he could only write letters. When interviewed, on 29 November 1976, he described the problems which he had had to face.

Figure 4.1 Yeast production and sales of Yeast Producers (Mtius) Ltd.



He explained how their yeast was an unknown brand in competition with the well-known brands of a handful of yeast manufacturers who dominate the world yeast export markets. In the importing countries the bakers are a small group who have traditional suppliers, while agents are few and far between, and often tied to particular exporters. (For example, in Mauritius, Ireland Blyth used to import DCL yeast and M.A. Cassim imports 'Saf levure'). Even in countries which imported yeast through government agencies by competitive tenders, the Mauritian yeast had difficulty in penetrating the market; in Tanzania, for example, they were never invited to tender (perhaps through not having established personal interests in the right quarter).

M. Hugnin then outlined their problems in shipping the few orders they did manage to win. They had had difficulties with inferior quality packaging, which suffered a lot of breakage on their second shipment to Bombay. The shipping dates of well-known lines were delayed, while they were often forced to use tramp steamers and indirect routes, including a, supposedly, direct shipment to Sri Lanka which was trans-shipped at Bombay, the tins left out in the sun for some time and then taken to Sri Lanka, to arrive three months after the shipment had left Mauritius. The freight rates themselves were high for the distances involved, compared with the rates on routes with more traffic, such as those used by their competitors from Europe to the countries around the Indian Ocean.

The only large customer the company supplied was in Sri Lanka. After these events, receiving yeast months late, and finding that in this time the yeast had lost its activity, they ordered no more. Indeed, it seems that they did not even pay for this shipment, as the



accounts for July to December 1977 show a debt of Rs38 075.83 owed by the Co-operative Wholesale Establishment, Sri Lanka. This debt was to have been written off on 30 June 1978(3).

Unsurprisingly, the company was loosing money as the unsold stocks accumulated and much of the factory capacity remained unused. So they started searching for a new foreign partner, as Anchor Yeast had refused to put any more money into the company (or even the amount to which they had initially agreed). They were interested in finding a company that would market their yeast and put in money into the company, to enable them to pay off some of the ever increasing loans.

They had talks with a Dutch company, one of whose representatives visited Mauritius, but these came to nothing. Eventually, they came to an agreement with Lallemand Inc., a Canadian yeast company which had supplied markets in the Far East previously, but had had to pull out to supply an increasing home market. Lallemand agreed to market the yeast produced by the Beau Champ factory under their name, and sent engineers to Mauritius to change the process conditions so that they could produce yeast which would retain its activity after long delays in shipment. They did not agree to invest in Yeast Producers (Mtius) Ltd. The agreement began on the 1 March 1977, and as shown in figure 4.1, led to greatly increased sales, which often exceeded the production.

The large initial sales of reject yeast (as feed yeast) were from the stocks produced earlier under Anchor Yeast technology. They initiated extra tests for activity, and only found six tonnes which were of a high enough standard to export as active bakers' yeast.

This yeast lost 67% of its activity in six months(4). The production manager had been misled by <sup>the</sup> accelerated aging test, he had learned in South Africa, of keeping the yeast at 45 °C for 8 days, supposedly equivalent to storage in normal conditions for one year. Under this test the yeast lost only 40% initial activity(5). But the conditions on ships and on docks in India are closer to the 45 °C test than the 'normal' conditions.

The Lallemand engineers worked with the Mauritian staff, improving the driers and the fermentation and drying schedules, and carrying out experiments to optimize the quality of the yeast produced. In this way the Mauritians learned from them, and later M. Duvergé was able to set up his own programme of experiments to increase production(6).

Meanwhile, the Lallemand marketing staff began looking for customers for the yeast produced in the Mauritian plant. They found customers in Sri Lanka, Jordan, Indonesia, Kenya, Moçambique, Lebanon, Hong Kong and the Seychelles. Then they, too, came up against the problems of being 'sea-locked'. As Mr. Chagnon, who was then marketing director of Lallemand Inc., explained in a letter:(7)

The first and foremost problem, and only insoluble one, was the impossible shipping situation from Mauritius to any market other than Mauritius itself. The port was often on strike, ships would often cancel their scheduled stop at Port Louis because of "congestion" and there were few if any direct service lines to markets other than Europe, South Africa or Singapore. This is why we had to set up an expensive entrepot operation in Singapore to service our customers in Lebanon, Jordan, Kenya, Moçambique, Sri Lanka, Indonesia and yes, even the Seychelles.

When interviewed, one of the directors of Compagnie des Transports Commerciaux in Port Louis, a firm of shipping agents who handled the yeast shipments for Lallemand Inc., confirmed the lack of

direct shipping lines to most markets. Sometimes there would be a Clan Line ship to Sri Lanka, otherwise they would have to export via Bombay or Singapore. Yeast for Jordan would be put in a container, shipped to Marseilles, then from Marseilles to Aqaba, and then overland to Amman. He said it took two months from leaving Mauritius to reach Aqaba. The whole journey to the customer took longer at times, as Mr. Chagnon wrote of this route to Jordan, "This mean (sic) up to a six month period of incubation for the dry yeast in a container at temperatures up to 40 °C."

Shipping costs over such devious routes were high. To quote Mr. Chagnon again:

Cost of shipping was also as a result prohibitive and we determined that it was much cheaper to ship from our Montreal plant to Kenya than from Mauritius.

Freight costs and commissions are given later in this chapter in figure 4.10.

While the export sales were steadily increasing, local sales remained sporadic, as shown by the following quotation from the first market survey the company carried out into the local market, in October 1977 - more than two years after starting production(2).

La vente totale à la Mauritius Cold Storage pour l'année financière 76/77 se terminant au 30 juin 1977 n'a été que de 18 000 kg, ce qui se comparant à un marché local estimé à 80 000 kg par an - chiffre obtenu des statistiques de la douane - démontre un net manque d'agressivité de notre distributeur exclusif.\*

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\* The total sales to Mauritius Cold Storage for the financial year 76/77 ending on 30 June 1977 were only 18 000 kg, which compared with a local market estimated at 80 000 kg per year - figure obtained from the customs statistics - shows a clear lack of aggression on the part of our exclusive distributor.(my translation)

At this late stage they started paying attention to the needs of the local bakers, and why they continued to buy imported yeast at higher prices than the locally produced product. The authors of this survey proposed direct selling to the bakers, from a van based at the factory, but this was never taken up by the directors of the company.

Indeed, by the beginning of 1978 it was becoming clear that the losses were continuing (although not at the rate of the first two years production), and the directors decided to close down and sell the plant. The last production was in April 1978, the stocks of dried yeast were sold between May and November with a large quantity going to Lesaffre, their competitor in Indonesia. Finally, some 60% of the equipment was bought by an Australian company for erection in Sri Lanka.

According to M. Duvergé, the final loss was of the order of five to six million rupees, of which three million rupees were recovered by the sale of equipment. The package boiler was to be sold locally, and Beau Champ were to find another use for the building, perhaps recovering another million rupees. When I visited him in January 1979 they were packing away the last of the equipment which had been sold, the building was being used as a storeroom, and M. Duvergé was working as a planters' advisor from his office there.

This case raises several important questions concerning; the process of technology transfer (and the differences between the two occasions on which this occurred); decision making in Mauritian industry (and the effects upon it of the lack of information exchange between different elite social groups); the nature of the interna-

tional yeast market; the effects of exporting from a sea-locked economy; and whether dried yeast production could be a technology appropriate to a small island at all.

The rest of this chapter is devoted to analysing this case, with a view to finding answers to these questions. A description of the production process is followed by an analysis of the financial results of the operation to determine what changes were brought about by the intervention of Lallemand Inc., and which factors most affected the profitability of Yeast Producers (Mtius) Ltd. Finally, the more important factors, and how they bear upon the above-mentioned questions, are discussed in greater detail.

## 2. The Production Process

This can be considered as the sum of three sets of processes and operations, the preparation of the growth medium (wort), the multiplication of the yeast by batch aerobic fermentations, and the separation and drying of the yeast produced.

The wort was prepared by continuously sterilising a mixture of molasses at 83 °Brix and filtered chlorinated water as shown in figure 4.2. This mixture is heated to 100 °C by a heat exchanger, and then raised to 120 °C by injecting live steam. The mixture was held at this temperature for three minutes, which should be enough to kill most microorganisms which might infect the yeast culture.\* During the sterilisation colloids coagulate and on cooling to 95 °C these are precipitated, and removed in a clarifying centrifuge. This centrifuge is shown in figure 4.3, alongside the plate heat exchanger used to

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\*In the UK, for example, DCL at Menstrie sterilise at 130 °C for half a minute only.

save energy in the sterilisation process.

Figure 4.2 Wort sterilisation.

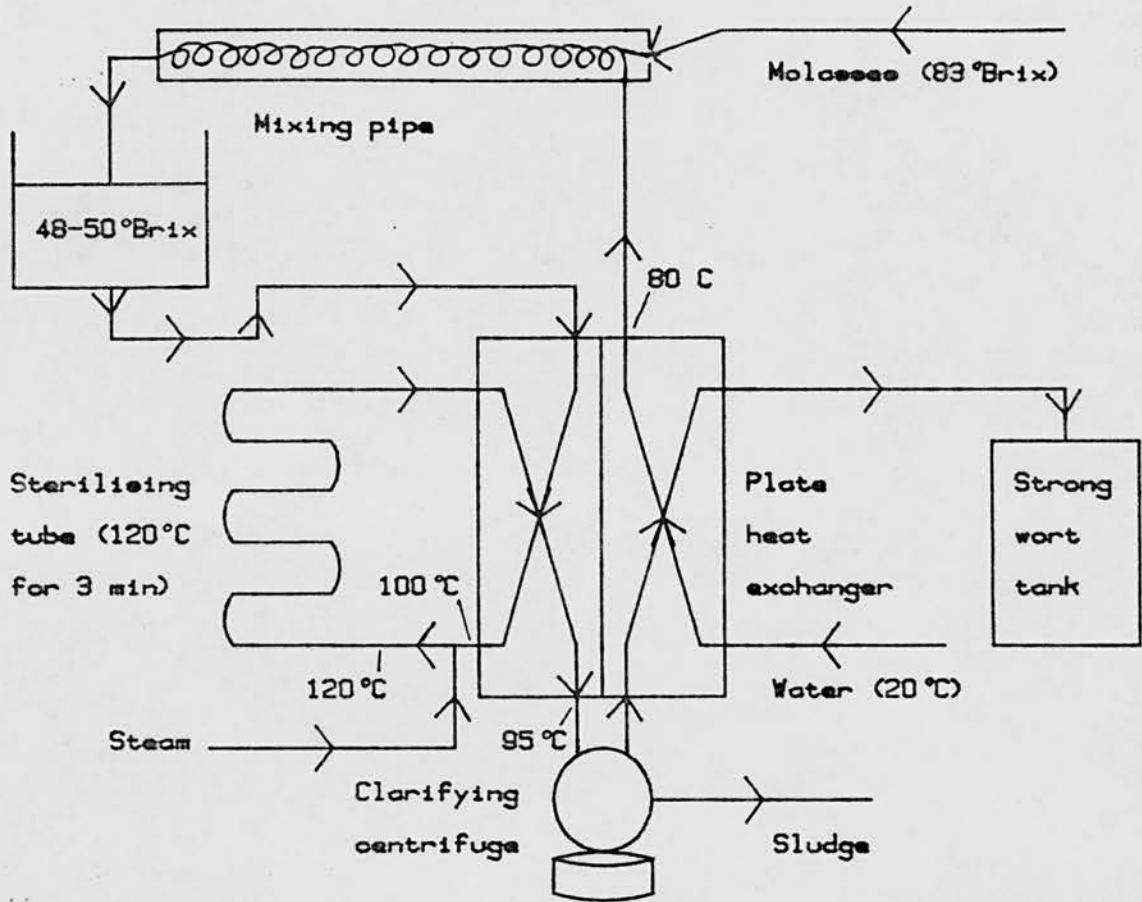
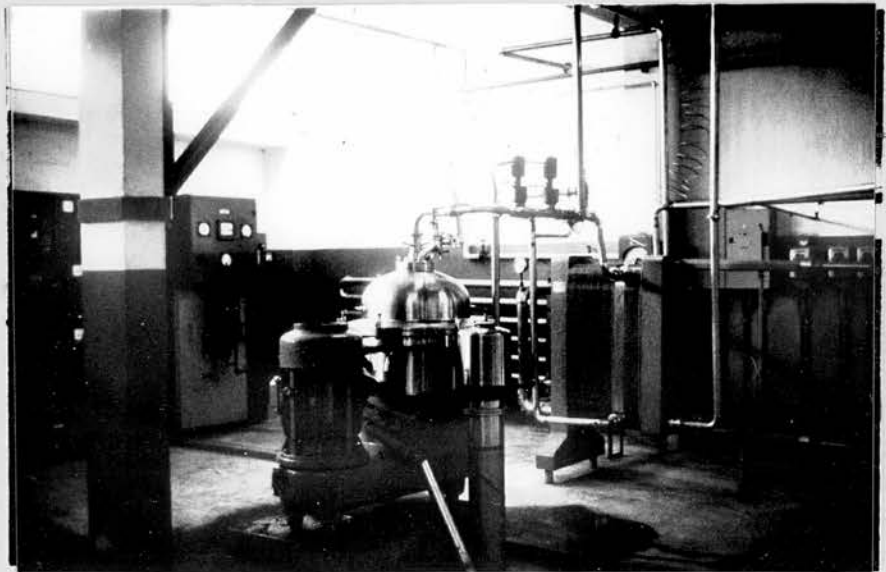


Figure 4.3  
Heat ex-  
changer and  
clarifying  
centrifuge  
(July 1976)



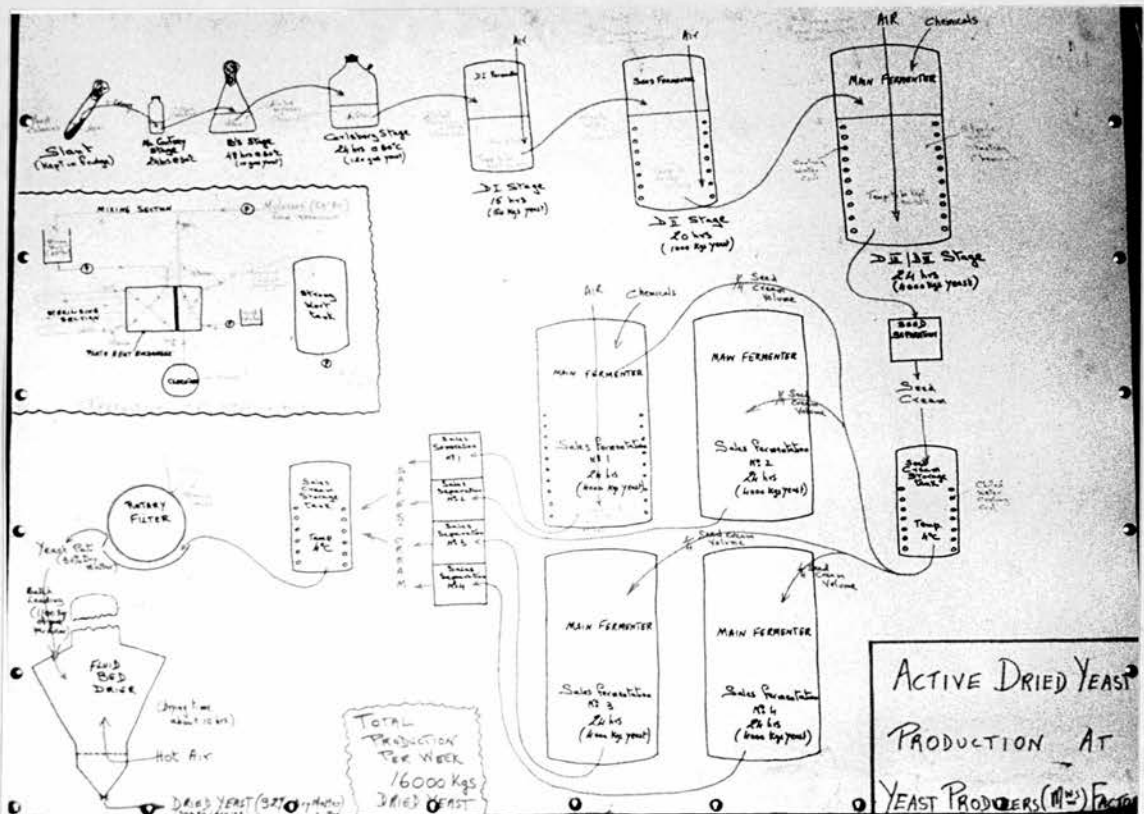
Such continuous sterilisations not only save the time otherwise



needed to sterilise the wort in the wort or fermentation tanks (fifteen minutes to several hours depending on the organisms one wishes to destroy plus a long heating and cooling time(8)), but also reduce the destruction of nutrients in the molasses(9).

In contrast to the continuous wort sterilisation, the fermentation itself was a batch process. The yeast was propagated from an agar slant, on which was a pure culture of a strain of Saccharomyces cerevisiae selected for use as a dried bakers' yeast, to 15 ml glass flasks in the laboratory, grown on McCartney medium for one day until there was enough yeast to inoculate a one litre flask containing sterile molasses medium. The yeast was then grown, on an ever increasing scale, on sterile wort, in stainless steel welded tanks, in the factory, as shown in figure 4.4.

Figure 4.4 Yeast propagation cycle used (July 1976)





Extensive precautions were taken against the risk of infection. Before every fermentation, except the final sales fermentations, the tanks were washed with detergent and then sterilised with steam for eight to ten hours. To ensure that no infections entered with the wort or added chemicals, in the 10 l and 700 l (D1\*) stages, all the wort and chemicals were placed in the vessel and sterilised, in situ, by passing steam through the mixture before the yeast was added. From the D2/3 stage onwards chemicals and wort from the continuous steriliser were added, from time to time, during the fermentation to replace exhausted nutrients, and sulphuric acid was introduced as necessary to maintain a pH sufficiently acid to inhibit bacterial growth. Yet, despite these precautions infections did occur during the first months of operation. As mentioned earlier, these infections were traced to the air which was blown vigorously through the medium to provide oxygen for respiration of the yeast cells (without air yeast produces ethanol rather than more yeast). As the aeration requires between 20 and 30 m<sup>3</sup> air/kg yeast produced(10), this afforded ample opportunity for wild yeasts to infect the medium until an air filter was installed. An idea of the scale of the aeration can be obtained from figures 4.5 and 4.6 which show an aerator in detail, with its large tubular air outlets, and the inside of a fermenter looking down from the top past the stainless steel cooling water coils to the aerator at the bottom.

As can be seen from figure 4.6, the fermentation tanks are lined with cooling tubes. These are needed to maintain the temperature at 30 °C, as higher temperatures result in lower yields of yeast, poorer

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\* D1 etc. are standard terms used in the yeast industry to refer to stages in the propagation and growth of yeast.

Figure 4.5  
Detail of  
aerator in-  
side fer-  
menter (July  
1976)

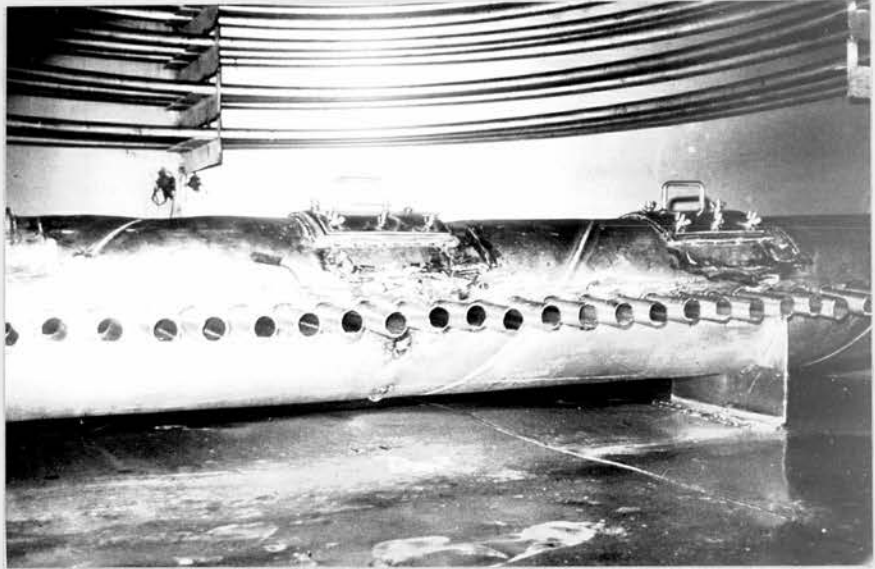
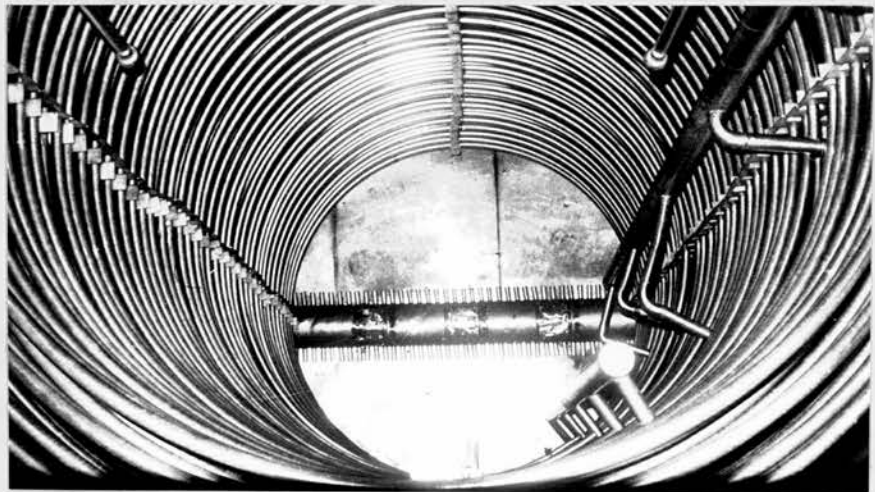


Figure 4.6  
Internal  
view of a  
fermenter  
(July 1976)



quality yeast, and an increased risk of infection from thermophilic bacteria which are the most likely to survive the sterilisation. Only in the final sales fermentations was the temperature allowed to rise to 35 °C at the end of the fermentation, causing the dry matter content of the yeast to increase.

These temperatures reflect the standard practice of the yeast industry, but are more often hoped for than achieved in tropical

countries. This factory was fortunate to be sited close to the Grande Rivière Sud Est, one of the largest rivers on the island, from which it could draw as much cooling water as it required.\*

In each series of fermentations, after the first fermentation in the main fermenter (D4), the seed yeast produced was separated, in a centrifuge, from the wort as a 22% solids cream. After being washed, this seed yeast was stored in a tank at 4 °C. At this temperature the yeast's metabolism is very slow, so it can be kept for some time without adding extra nutrients. About one quarter of this yeast was then used to seed a sales# fermentation in the main fermenter. This fermentation differed from the others by reduced attention to sterility and by starting with a more dilute initial mixture, to which additional strong wort was added throughout the fermentation.

The yeast produced was then separated in a centrifuge, again in the form of a 22% dry matter cream. Salt was added to the cream to remove water from the cells by osmosis and the cream was then filtered, through a starch layer on a filter cloth on a rotary vacuum filter (see figure 4.7), to produce a 30% solids paste. This paste was fed into the top of the drier.

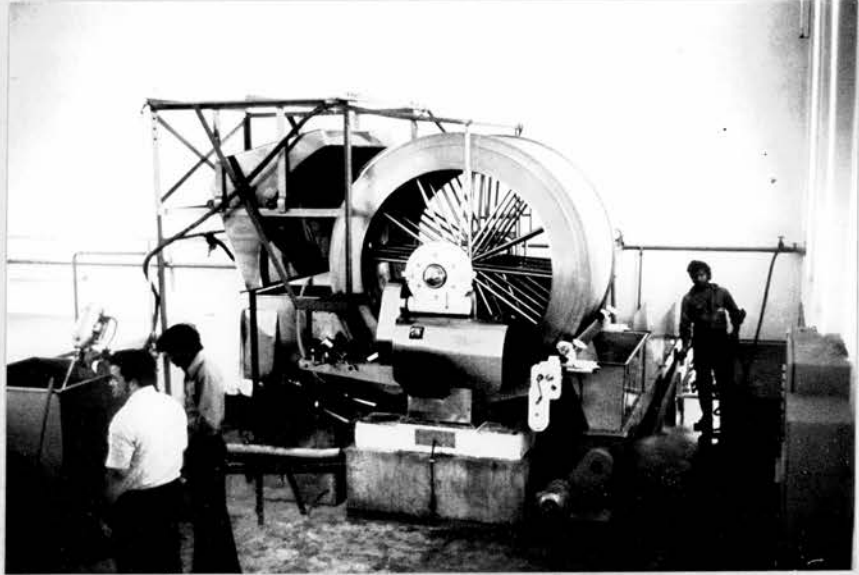
This drier had been described to M. Duvergé by the Anchor Yeast engineers as a 'fluidised bed drier'. In fact, it was a tower drier, which could be described as a spouting bed drier - hence its tall, narrow shape. When the Lallemand engineers, together with the factory manager, studied the operation of this drier they found that the yeast fell onto the bottom plate where it stayed until it was nearly dry,

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\* This was possibly one of the reasons why the yeast factory came to Beau Champ rather than some other sugar factories.

# A fermentation designed to produce yeast for sale rather than for seed.

Figure 4.7  
Rotary vacuum  
filter for yeast  
(being  
cleaned,  
July 1976)



producing local overheating as shown by the proportion of oversized pellets produced. These pellets had to be ground up and sold at a discount on the local market.

The yeast was dried for six hours at 50 °C followed by six hours at 70 °C, producing 450 kg of dry yeast (92% dry matter)(11). The output was then packed into 1 kg tins or 25 kg polythene bags (for export), or 1 kg or 5 kg plastic bags (for local sales). Yeast with no immediate prospects for sale was bagged in 25 kg or 40 kg plastic bags and put into their cold store.

All stages of the process were monitored by a series of quality control tests, of the chemical and microbiological quality of the yeast, and of the presence or absence of contaminating microorganisms. Some 50 to 60 microbiological and chemical analyses were made per week under South African practice, which number increased to 300 per week under Lallemand. (This required the services of a laboratory technician for 34 hours/week). The tests introduced by the Lallemand engineers were also more rigorous, as shown by the reclassifi-

cation of the yeast produced before February 1977 - only six tonnes were of export quality as against 238 tonnes of feed quality under the new classification(12). An acceptable result of 120 mm Hg initial baking activity (measured as the pressure of CO<sub>2</sub> produced in a standard test) and 70 mm Hg after being kept at 45 °C for eight days(5), became an unacceptable 33% loss in activity over six months under the Lallemand tests(4).

### 3. An economic analysis of the venture

According to M. Duvergé, the original feasibility study presented by Anchor Yeast was very brief and simple. It assumed that the factory would produce 800 t/a and that they would be able to sell all of this. They assumed<sup>that</sup> the company would need little working capital to finance unsold stocks of yeast, and that raw material costs would remain constant. Such simplistic assumptions are typical of certain types of bad feasibility studies.

To counter such an idealist approach, the present analysis of what actually happened in the case of Yeast Producers (Mtius) Ltd., shows not only the pitfalls of simplistic project appraisal, but also <sup>attempts</sup> to determine the key factors which affected the results of this company through a sensitivity analysis of how they affected the losses.

Through studying the reactions of the participants, in this enterprise, to the problems encountered it should also be possible to see if the mechanisms described by Hirschman came into play here - the feasibility study serving the promotional function of persuading cautious investors to invest in a new enterprise, which they might not have considered if they had known all the problematic factors involved; then, having invested in the project, they are forced to



overcome these problems as and when they occur; in overcoming the problems they gain experience from this creative activity. In this way they acquire the knowledge and confidence which they can apply to their next venture(13).

Turning to the analysis of the economics of this yeast factory, it is necessary first to consider the production and sales figures, already given in figure 4.1. There is an obvious difference between the periods before and after 1 March 1977. The sales lag far behind production up to February 1977 (121 t active yeast sold out of 363 t produced), whereas after March 1977 both increased to appreciable levels (about 45 t produced and 30 t sold per month). This change corresponds to the beginning of the agreement for Lallemand Inc. to market the yeast produced by Yeast Producers (Mtius) Ltd.. The data falls naturally into two periods, an initial period using the technology supplied by Anchor Yeast and Mauritian marketing, and the period after 1 March 1977 when the factory depended on Lallemand for marketing and technology.

On considering the sales of reject yeast (sold as animal feed yeast both to Singapore and in Mauritius), large quantities were sold in May, July and October 1977. Most of this yeast was produced before March 1977, using Anchor Yeast technology, and sold later as feed yeast when it was found that the yeast was not active enough to serve for baking. The stock figures for the end of February 1977 give only 6 t of yeast for export, but include 238 t of feed quality yeast(4).

Taking this into account, it is possible to calculate the fate of the yeast produced before and after 1 March 1977. This is shown in figure 4.8 together with the breakdown of active yeast sales into

local and export sales.

Figure 4.8 Destination of production

	Prodn. under technology of:				Total /t
	Anchor /t	Yeast %P	Lallemend /t	%P	
Production (P)	363	100	644	100	1007
Active yeast sales:					
local	14	4	52	8	66
export	112	29	546	85	653
total	121	33	598	93	719
Rejects: unsold	23#	8	0	0	29
sold for feed	214	59	46	7	260

# Made up of twenty tonnes written off after being stored without refrigeration in plastic sacks at Ferney sugar estate until no longer active. These were lodged there out of sight so as to prevent a visitor from a Dutch yeast company seeing the vast stocks of unsold yeast. Other yeast was lost during transport to and from such lodging places when bags split open, and two tonnes were stolen from the factory(12).

From this can be seen that an important achievement of the Lallemend engineers, and their Mauritian colleagues, was the reduction of the proportion of yeast which had to be rejected from 66% to only 7%. As the yeast cost over Rs5/kg to produce, and the factory received only Rs0.50/kg for sales of feed yeast, this reduction in rejection rates had an important influence on the losses.

To quantify these losses it is necessary to calculate the production costs and the receipts from sales. Starting with the latter, the July to Dec. 1977 accounts give the freight costs and commissions for some of the export shipments made in this period and before(3). These are summarised by destination in figure 4.9

This shows clearly the effect of the high freight rates from



Figure 4.9 Freight costs and commissions for exports in 1977, by destination

Destination	Quantity t	Received (Net) Rs/kg	Commissions		Forwarding + Dock Dues Rs/kg	Total Value Rs/kg
			Importer Rs/kg	Lallemant Rs/kg		
Jordan	90	4.30	0.35	0.27	2.00	6.92
Sri Lanka	90	7.43	0.47	0.47	1.03	9.40
Singapore	31.8	6.05	0.08	0.36	0.72	7.21
France	18	4.96	0	0.32	1.16	6.44
Hong Kong	8.5	5.90	0.35	0.38	0.33	6.95
Moçambique	2.5	4.06	0	0.28	0.17	4.51
Kenya	1	3.04	0	0.19	1.19	4.42
Seychelles	0.75	5.61	0	0.37	5.86	11.85
Madagascar	6	6.40	?	?	?	?
Australia	2	4.68	?	?	?	?
Neth. (1976)	16.56	5.90	?	?	?	?
Kenya (1976)	1.92	7.03	?	?	?	?
Feed yeast to Sing.	81.4	?	?	?	?	1.49

Mauritius, especially for indirect shipments such as those to Jordan (via Marseilles) and the Seychelles (via Singapore). Other examples of freight rates are Rs0.82/kg for a shipment of two tonnes to Mombassa in February 1978(14), and the following rates quoted by M. Hugnin in 1976: Reunion - Rs0.26/kg; Tamatave - Rs0.33/kg; Seychelles - Rs0.62/kg; Sri Lanka - Rs0.75/kg; Mombassa - Rs0.90/kg; Rotterdam - Rs0.90/kg; and Baghdad - Rs2.50/kg. All of these rates do not include dock charges, and so did not differ greatly from the 1977 figures.

The net receipts at Port Louis were often not very favourable, especially as these prices include the packaging. They were also high, as shown in figure 4.10, in which is summarised the different costings of packing and transport made at different times for Yeast Producers (Mauritius) Ltd. Such high costs are to be expected on 'sea-locked' islands, as the plastic and steel needed to produce the con-

tainers is all imported, at similarly high import transportation costs.

Figure 4.10 Costs of packing and transport to Port Louis(15,16,17,2)

Source: Packed in	Costs in Rs/kg:			
	Labour	Materials	Transport	Total
Feb. 1977 costing:				
1 kg tupperware	0.05	2.30	0.04	2.38
25 kg polythene bags				
-in carton	0.05	0.44	0.04	0.52
-in twill bag				
-in container	0.05	0.16	0.04	0.25
-on pallet	0.05	0.30	0.04	0.39
18x1 kg plastic bags	0.05	0.75	0.04	0.83
4x5 kg plastic bags	0.05	0.38	0.04	0.46
Dec. 1977 costing:				
1 kg tins	0.05	1.00	0.05	1.10
Local sales report:				
20x1 kg plastic bags	0.05	0.71	0.05	0.81
4x5 kg plastic bags	0.05	0.36	0.05	0.46
1978 costing:				
2.5 kg tins	0.05	1.30	0.08	1.43

The shipments to Jordan and France were in 25 kg polythene bags inside twill bags packed in 18 t containers, many of the shipments to Singapore were in polythene bags on pallets, the early Australian shipment was in 25 kg polythene bags each in a cardboard box, the local sales were in boxes of 20x1 kg and 4x5 kg plastic bags, and that those to Mombassa and the early sales to Sri Lanka were in 1 kg tins(18,14). Making reasonable assumptions for the other shipments, it is possible to estimate the receipts at the factory for each kilogram of yeast produced. This has been done and is shown in figure 4.11. These are prices in the cold store, or at the drier outlet, as they also are net of packing labour (up to ten men

at a time, hired when there was packing to be done).

Figure 4.11 Calculation of factory price

Destination	Prices (Rs/kg):		
	Factory (in store)	Packing & Transport	Net Received
Jordan	4.04	0.26	4.30
Sri Lanka	6.33	1.10	7.43
Singapore	5.65	0.40	6.05
France	4.70	0.26	4.96
Hong Kong	4.80	1.10	5.90
Moçambique	2.96	1.10	4.06
Kenya	1.94	1.10	3.04
Kenya(1976)	5.03	2.00	7.03
Seychelles	4.51	1.10	5.61
Madagascar	4.02	2.38	6.40
Australia	4.16	0.52	4.68
Netherlands(1976)	3.90	2.00	5.90
Local sales:			
-20x1 kg bags	6.94	0.81	7.75
-4x5 kg bags	7.29	0.46	7.75

We see that the most profitable sales were to the local market, as no freight had to be paid on these. Indeed, some imported yeast sold in Mauritius at Rs12.00/kg (to the baker)(2). Some of the other prices are very low, even Rs2/kg. Such prices represent attempts to enter new markets by selling at a loss, or when forced to sell at low prices by competition from established suppliers. In Indonesia, a French company sold its yeast at half price for six months until Yeast Producers (Mtius) Ltd. were forced to withdraw from the market after loosing one million rupees(4).

There have been several production costings made during the lifetime of the plant. The variable costs have been summarised in figure 4.12. The steam usage has been divided between sugar factory steam and steam produced in an oil-fired package boiler, according to

the time Beau Champ sugar factory was in operation during the times yeast was being produced. The electricity cost does not include the fixed maximum demand charge, paid whether any is consumed or not, which is better considered as a fixed cost.

Figure 4.12 Variable production costs under Anchor Yeast and Lallemand operation(15,16,19,10).

Item	Usage/t Paturau	ADY under technology of:			Unit costs/Rs		Total costs	
		Anchor Initial	Yeast 2/'77	Lalle-mand	Anchor 2/'77	Lall. 12/'77	Rs/t Anchor	ADY Lall.
Molasses/t	3.4-4.3	5	5.05	5.09*	180	200	909	1018
Chemicals/kg:								
Urea	0	150	132	120	2.50	1.90	330	228
Di-Amm.phosphate	0	35	37.4	40	3.90	4.45	146	178
Superphosphate	120	0	0	0	?	?	0	0
Ammon.sulphate	53	3.0	4.2	0	1.00	?	4	0
Mg sulphate	0	3	3.8	0.8*	2.72	3.00	10	2
Sulphuric acid	50	3.5	4.8	4.2*	3.50	4.00	17	17
Starch	?	100	100	97*	3.30	2.75	330	267
NaCl	?	125	151	212*	0.45	0.55	68	117
Defoamer	?	)	27.4	25	4.30	4.60	118	115
Gly.monostearate	?	)	6.3	6	7.00	7.00	44	42
Detergents	?	)20	7.3	3	2.85	4.00	21	12
Ca hypochlorite	?	)	8.4	3	2.30	13.00	19	39
Total for raw materials							2016	2035
Steam/t-factory	)5.8	10.3	11.5	6.3	4.02	4.02	46	25
-package boiler	)	4.7	5.3	9.7	33.28	50.00	175	483
Electricity/MWh	1.4	1.5	2.39	2.47*	260#	350#	621	865
Water/m <sup>3</sup>		150	87.5	103*	0.10	0.10	9	10
Total for services							852	1384
Total variable costs							2868	3418

\* Average consumption over July 1977 to April 1978.

# From CEB annual reports.

Of the modifications to the process introduced by Lallemand, the only ones which significantly affected the raw materials and services costs were the increased usage of salt and electricity (to improve drying and aeration), and an increase of production outside the cane

crushing season (as they were selling more). The plant does, however, use substantially more molasses, steam and electricity than the plant designs quoted by Paturau(10), this suggests it was not designed with energy economy in mind, and that the yield on Mauritian cane molasses was lower than on the cane and beet molasses mixtures used in other plants.

Note that the total variable costs of Rs2.87/kg and Rs3.42/kg were higher than the sales income at the factory, for some of the sales, thus establishing a loss on these sales even before consideration of the fixed costs. These fixed costs are presented in figure 4.13. This is based on the pro-forma accounts for July-December 1977(3), and the costing, prepared in February 1977, based on 1976 operating costs(15).

The accounts were for six months, so the estimated annual equivalents were obtained by doubling these figures with two exceptions: the maintenance costs were taken from the production costing made at the same time(20) as the maintenance and repairs may not have been distributed evenly throughout the year; and the electricity demand charge was separated from the electricity costs in the variable costs and placed here.

As the February 1977 costing was produced in the factory, it does not include costs for the Port Louis administration. These have been estimated from the July-December accounts, further taking into account salary increases, a probable increase in licence payments (to Lallemand as well as Anchor Yeast), and charges for travel abroad in connection with the Lallemand marketing (M. Hugnin did not travel abroad to sell yeast). Where actual figures were given for January to

Figure 4.13 Annual fixed costs (kRs)

Item	Accounts As given	7-12/'77 Estim. annual equiv.	Costing As given	2/'77 Plus est. items
Management & labour	240.404	481	427	427
Pension contrib.			30	30
Medical expenses			10	10
Factory expenses	20.188	40		
Maintenance	70.904	88	85	85
Elec. demand charge		180	119	119
Rent of cold room	33.320	67	63	63
Insurance	18.778	38	36	36
Port Louis admin.:				
Salaries	138.169	277		245
Professional fees	11.200	22		22
Licences	12.440	25		12
Office	19.972	40		40
Travel abroad	15.468	31		0
Tot. before dep.		1288		1089
Depreciation	220.566	441	434	434
Tot. before int.		1729		1523
Interest paid	358.916	718	450	450
Total fixed costs		2447		1973

September 1976 consumption, in the body of this costing, they have been used for the calculation of the items in the table rather than have M. Duvergé's assumptions.

Notable amongst these figures are interest charges, administrative salaries, electricity demand charge and rent of a cold room in Port Louis. This last was necessary because the cold room at the factory was full of unsold yeast. The electricity demand charge is a remarkably high proportion of fixed costs, over 10% of the total before financial charges. The competitors of Yeast Producers (Mtius) Ltd. and Lallemand, in Montreal, paid far less for electricity. The

administration salaries were more than half the salaries of the 28 workers in the factory and the production manager and his assistant. Even if the salary of an accountant at Rs80 000 per month were included in the administration salaries, they would still seem excessive for the work of correspondence with Lallemand and the local agents, and preparing the accounts. All the other work was done at the factory.

The crippling level of interest payments was a consequence of the high gearing of the company, and the need to pay interest on loans raised to cover the accumulated losses. By 31 December 1977 the revenue deficit had reached Rs5 241 617(3).

The estimates of variable costs, fixed costs, and factory revenue given in figures 4.12, 4.13 and 4.11, have been used to calculate the total annual costs and revenues and hence the annual losses during the two phases of operation (under Anchor Yeast technology, and under Lallemand technology). To simplify this and subsequent calculations the sales of yeast produced under a particular technology have been attributed to the period of production. (In this way the financial consequences of having to sell yeast produced before March 1977 as feed yeast are clearly shown in the figures for the Anchor Yeast period). The results are given in figure 4.14.

Figure 4.14 Annual production costs, factory revenue and losses before and after 1 March 1977

(MRs/a)	Production costs			Factory Revenue (R)	Losses (L)
	Variable (V)	Fixed (F)	Total (T)		
Anchor yeast	0.7	2.0	2.6	0.5	2.1
Lallemand	1.9	2.4	4.3	2.8	1.6



The table shows the five-fold increase in revenue, after 1 March 1977, as the sales of good yeast increased under Lallemand marketing and production technology. The increase in production led to a reduction of the proportion of fixed costs, in the total costs, from three-quarters to a half of the total production cost.

As a check on these calculations, the losses for the periods 1 July - 31 December 1977 and from the start of production to 30 June 1977 were calculated and compared with the revenue deficits for the same times given in the accounts for July - December 1977(3). This was not easily done, as the accounts contained internal inconsistencies. The total sales listed in Schedule 8 were 324 442 kg whereas the total given in the pro forma cost of sales table was 399 591 kg. Also, the total payments made for forwarding and docks dues and for commissions listed in Schedule 8 were more than the entries for the same in the pro forma profit and loss account. The difference of 75 t appears to correspond to the 75 000 kg stocks of yeast in Singapore, mentioned in Schedule 2, and to shipments of 75 t to Sri Lanka in the factory records(21) not included in the list of sales in the accounts. So these 75 t of yeast were probably in Singapore awaiting sale and shipment to Sri Lanka. Another 48 t of local sales of rejects as feed yeast in October 1977, recorded in the factory records, were ignored in the accounts (even M. Duvergé did not remember this sale until he checked his notes in July 1981).

The total sales revenue to the factory during these six months was then calculated, by multiplying the quantities sold to each destination (from Schedule 8) by the factory price (from figure 4.11) and subtracting an estimate of the packing cost of the 75 t in stock in Singapore (at Rs1.10/kg), assuming that the freight costs on this

would not have been paid until the yeast was sold, that is after December 1977. The variable costs were taken from figure 4.12, assuming the feed yeast was produced before 1 March 1977, and the fixed costs from figure 4.13.

On this basis, the loss between 1 July and 31 December 1977 was calculated as Rs1.01 M which compares with Rs1.07 M (before extraordinary items, and corrected for the slight errors in commissions and freight charges) in the accounts.

Applying the same calculation to the operation up to 30 June 1977, the losses were calculated as Rs3.8 M whereas the total revenue deficit at 30 June 1977, as recorded in the pro-forma balance sheet for 31 December 1977, was Rs4.2 M. This difference reflects the accuracy to be expected from these calculations. As the costings for the operation under Lallemand technology and marketing were derived from these accounts, it is not surprising that the calculated losses for July to December 1977 agree so closely with those in the accounts.

To check on assumptions made in the preparation of the costings and sales revenue estimates, a sensitivity analysis was carried out on the effects of changing these assumptions. The results of this analysis are shown in figure 4.15.

The first check is on the simplifying assumption of attributing all sales of yeast produced before 1 March 1977 to that period. The alternative used here is to attribute the income from these sales to the period when sold. As can be seen in figure 4.15, this makes very little difference.\* Similarly, changing the assumptions for repairs

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\* Note that the costs and losses have been calculated for the whole operating periods under Anchor Yeast technology and Lallemand technology, then reduced to an annual basis for com-

Figure 4.15 Sensitivity analysis - check on assumptions made.

(MRs/a)	Anchor					Lallemand				
	V	F	T	R	L	V	F	T	R	L
Basic assumptions	0.7	2.0	2.6	0.5	2.1	1.9	2.4	4.3	2.8	1.6
Attr. sales to when sold	0.7	2.0	2.6	0.5	2.1	1.9	2.4	4.3	2.9	1.5
Maintenance cost	0.7	1.9	2.6	0.5	2.1	1.9	2.5	4.4	2.8	1.6
P.Louis admin. - free	0.7	1.7	2.3	0.5	1.8					
- same as Lallemand	0.7	2.0	2.7	0.5	2.2					
Interest payments - Rs 550 k/a	0.7	2.1	2.7	0.5	2.2	1.9	2.3	4.2	2.8	1.4
- Rs 800 k/a						1.9	2.5	4.4	2.8	1.6
Packing - cheapest	0.7	2.0	2.6	0.6	2.0	1.9	2.4	4.3	2.9	1.4
- most expensive	0.7	2.0	2.6	0.5	2.1	1.9	2.4	4.3	2.5	1.8
# Anchor>=Rs 50 k/a, Lallemand>=Rs 142 k/a										

and maintenance cost to Rs50 000/a for the Anchor Yeast period (the estimate used in the summary of the February 1977 costing), and to Rs141 808/a for the Lallemand period (twice the cost for the second half of 1977), makes no difference to the calculated losses.

Certain errors could have been introduced by the assumptions made concerning the Port Louis administration costs, before 1 March 1977, as the production costings produced at the factory did not include administration costs. As we see from figure 4.15, this can make a difference of around Rs0.2 M/a. Errors of the same size could have been introduced by the assumptions on the interest payments, as the Rs450 000, in the February 1977 costing, may have been based on 1976 figures, and the interest rates in Mauritius rose throughout the

parisons. This is consistent with the objective to analyse what actually happened. As a result, the Lallemand period is not analysed as a going concern, since some of the sales were made when the factory had shut down. While the factory was operating the average monthly sales were lower, and, hence, the monthly losses were greater. But to project this on an annual basis would imply ever-increasing stocks of unsold yeast, an even more arbitrary assumption than that of 800 t/a production and sales.

lifetime of the plant from 8.5% to 11.5% per annum for medium-term commercial bank loans between December 1976 and March 1978(22).

To summarise, it can be said that the figures based on these assumptions are accurate to no more than  $\pm 10\%$ . Nevertheless, they will serve for an analysis of which changes introduced by Lallemand had the greatest effect, and which factors most influenced the final outcome of the project.

Lallemand intervened in several ways. As a result of better marketing they sold more yeast, of both bakers' yeast and feed yeast quality. By modifying the production process their engineers and Mauritian colleagues improved the activity of the yeast produced, and reduced the proportion of rejects. With these changes in process came an increase in the production costs, both variable and fixed. In addition Lallemand took a commission of about 5% on export sales. In figure 4.16 is considered the effect of each modification on its own, e.g. the consequences of selling 551 t/a of yeast under otherwise Anchor Yeast conditions (with a high rejected proportion) and selling 229 t/a under Lallemand conditions. In each line of figure 4.16 the values for the given variable are interchanged.

Figure 4.16 Sensitivity analysis - Lallemand introduced changes.

(MRs/a)	Anchor					Lallemand				
	V	F	T	R	L	V	F	T	R	L
All Changes	0.7	2.0	2.6	0.5	2.1	1.9	2.4	4.3	2.8	1.6
Sales level	1.6	2.0	3.6	1.0	2.6	0.8	2.4	3.2	1.6	1.7
% rejects	0.7	2.0	2.6	1.5	1.1	1.9	2.4	4.3	1.1	3.2
Var. cost	0.8	2.0	2.8	0.5	2.2	1.6	2.4	4.0	2.8	1.3
Fixed cost	0.7	2.4	3.1	0.5	2.6	1.9	2.0	3.9	2.8	1.1
Commission	-	-	-	-	-	1.9	2.4	4.3	2.9	1.4

This table shows the great effect of improving the yeast so that it was of sufficient quality to ship over long distances and sell as active bakers' yeast. If the factory had just sold more without improving the quality, the losses would actually have risen. On the other hand, if under Lallemand yeast technology the factory had only sold the same amount of yeast as before, the losses would have been only slightly higher than they were.

The cost increases (variable, fixed and commission) had less effect, although

the factory would have lost half-a-million rupees a year less if it had kept its costs down. It must be remembered that these cost increases were only partly due to changes in operating procedures. There were substantial increases in labour and electricity costs at the same time.

The final part of this sensitivity analysis enables consideration to be given as to how the operation could have been made more profitable than it was, after the changes introduced by Lallemand had taken effect. This is given in figure 4.17.

From figure 4.17, the importance of the difference factors affecting the costs and revenues of the company can be evaluated. These are listed below in decreasing order of importance:

- i. Export price - if Yeast Producers (Mauritius) Ltd. had managed to sell all yeast produced at the best price received (from Sri Lanka), the losses would have been only a third of what they were.

Figure 4.17 Sensitivity analysis of Lallemand conditions to further changes

(MRs/a)	V	F	T	R	L
Lallemand conditions	1.9	2.4	4.3	2.8	1.6
Sales level - 800 t/a	2.7	2.4	5.2	4.0	1.2
- 900 t/a	3.1	2.4	5.5	4.5	1.0
Local market capture (62 t/a)	1.9	2.4	4.4	2.9	1.5
Export price - all at Rs 3.04/kg	1.9	2.4	4.3	1.8	2.6
- all at Rs 7.43/kg	1.9	2.4	4.3	3.8	0.5
Molasses price - Rs 100/t	1.6	2.4	4.0	2.8	1.3
- Rs 600/t	3.0	2.4	5.5	2.8	2.7
Steam price - all at Rs 4.02/t	1.6	2.4	4.1	2.8	1.3
- all at Rs 50/t	2.0	2.4	4.5	2.8	1.7
Elec. from sugar factory in season at Rs 0.10/kWh	1.8	2.4	4.2	2.8	1.4
Molasses use - 3.4t/t ADY*	1.7	2.4	4.1	2.8	1.4
Elec. use - 1.4 MWh/t ADY	1.7	2.4	4.1	2.8	1.4
Steam use - 5.8t/t ADY	1.7	2.4	4.2	2.8	1.4
Interest payments - Rs 0/a	1.9	1.7	3.6	2.8	0.8
Admin. cost - halved	1.9	2.2	4.1	2.8	1.4

ADY = air dry yeast.

- ii. Sales level - if there had been the markets to sell all the yeast the factory could produce, the sales income would have risen by half without any increase in fixed costs.
- iii. Interest payments - a great burden on the finances was the interest payments on the loans taken to cover the accumulated losses and the initial over-gearing of the company. If more share capital had been available in the early stages the company might have stood a chance of becoming profitable.
- iv. Molasses prices - the production cost is very sensitive to the molasses price. In mid-1981 the price of molasses in Mauritius reached Rs600/t. Under these conditions the factory could not have been profitable.

- v. Steam, electricity and molasses usage, steam and electricity prices - with the plant producing at about 65% of full capacity, these were relatively unimportant. Although the electricity cost was high, only small reductions could have been made by taking electricity from Beau Champ sugar factory during the cane crushing season, as the yeast factory would have to remain connected to the CEB grid for off season supplies and so would have to pay the maximum demand charge all year round.

#### 4. Discussion

The foregoing analysis has identified the most important economic factors which affected the failure of Yeast Producers (Mtius) Ltd. To summarise, these were, in decreasing order of importance, problems of market penetration and the returns on these sales, of quality yeast production, of the financing of the company, and of high production costs.

This statement leaves many questions unanswered. Why were Yeast Producers (Mtius) Ltd. not able to penetrate many Indian Ocean markets? How was it that the production technology was not easily transferred to an island of highly educated people, and where many people had substantial experience of running and controlling chemical processes and operations in the sugar industry? How did the company come to have such a low proportion of share capital? Why were the high production costs not foreseen?

Such questions do not lead to simple answers. To understand them a dynamic analysis is needed, studying not only how the economic situation of the factory evolved, but also how the participants understanding of this situation changed and how they reacted to their



understandings. To state, with the benefit of hindsight or on the basis of some set of idealist prescriptions, what the Mauritians involved should have done in an ideal world is inadequate - the world is not ideal, so what is necessary is to understand how they (or others in similar situations) react to certain concrete conditions. Such studies may lead one to an understanding of the mechanisms involved, of the operation of the "hidden hand" of Hirschman(13), and to how repetition of such failures might be avoided in the real rather than an ideal world.

The opinions of the participants on the marketing difficulties of Yeast Producers (Mtius) Ltd. should first be considered.

#### 4.1. Marketing

As mentioned previously, M. Hugnin, of Mauritius Breweries Ltd. and the Coca-Cola plant, was responsible for the export marketing of the yeast produced at Beau Champ for much of the time up to February 1977. In an interview with him on 29 November 1976 he claimed<sup>that</sup> the following factors were responsible for the poor sales:

- i. The yeast was of an unknown brand,
- ii. the international yeast market was divided between only a few firms, who reacted forcefully against any newcomers trying to enter their markets,
- iii. in most of the countries bordering the Indian Ocean bakers were a small group accustomed to traditional suppliers,
- iv. in any country there were few agents, who were often tied to large producers,

- v. certain countries had no foreign currency with which to buy yeast (e.g. Tanzania and Madagascar),
- vi. corruption (even in countries which bought yeast under competitive tenders by government bodies they were never asked to quote),
- vii. the packing material was of inferior quality. A lot of tins broke open on the second shipment to Bombay,
- viii. they had shipping difficulties. The shipping dates of well-known lines were delayed, and then the shippers broke their contract. Other lines (e.g. the Shipping Corporation of India) were very irregular, and once a supposedly direct shipment to Sri Lanka was transhipped in Bombay, where the tins were abandoned for some time until they were finally taken to Sri Lanka to reach the much displeased buyer, and
- ix. the freight rates were high.

This understanding of the sales difficulties was shared by the production manager, M. Duvergé, when interviewed in August and November of that year. In August, he had not seemed too surprised by the delay in obtaining orders, explaining that the factory had had to produce yeast samples before they could start selling. Later he realised that the baking activity of the yeast was greatly affected by the long journeys between factory and consumer, and ascribed the lack of repeat orders, in the early phase of operation under Anchor Yeast technology, to the poor keeping qualities of the yeast. He continued to assert that the full sales potential of the factory was limited by unfair competition from the big yeast manufacturers, giving as an

example (during an interview in January 1980) the reaction of a French company to an attempt to break into their market in the Far East. This company dropped their price, forcing Yeast Producers (Mtius) to sell at a loss for a year, until they had to give up after loosing one million rupees.

In contrast to this interpretation of the yeast market is that of Mr. Chagnon of Lallemand Inc. He has already been quoted on the difficulties and costs of shipping from Mauritius earlier in this chapter. About the yeast market he claimed:

The world yeast market is no different than may (sic) other markets, it is not the exclusive preserve of any "special" producers. The major ones are simply the most cost effective quality producers. Us smaller companies simply have to work harder to improve our efficiencies to meet the lower prices they sometimes use to "buy" out a market or to defend their established markets.

Note that he did not deny that the major producers bought out markets, but the interpretation is inspired by optimism rather than pessimism - it is possible, not impossible, to penetrate yeast markets.

What evidence is there concerning the openness or otherwise of the yeast market? Firstly, it is necessary to define which yeast market. It is a market for active bakers' yeast, which can ferment/respire in dough and by so doing grow quickly, causing the dough to rise. Bakers, unlike distillers, are not interested in the performance of the yeast over a 24 hour fermentation.

Of the active yeast produced, much is in the form of pressed yeast, containing about 30% solids, rather like the yeast cake that was fed into the drier at the Beau Champ yeast factory. Pressed yeast has limited keeping qualities, so the pressed yeast factories only

supply their own immediate adjacent market. Smaller communities and cities without pressed yeast factories use dried yeast.

In developed countries much of the dried yeast used is produced locally or regionally, whereas many developing countries still depend on imports from developed temperate countries, often from their former colonial rulers(23). It is the sales of active dried bakers' yeast to these countries which constitutes the international dried yeast market. It was into this market that Yeast Producers (Mtius) Ltd. tried to sell, in selling to countries bordering the Indian Ocean. And, as they had carried out no market survey before setting up the plant, they had no idea of the size of the markets they were entering, or whether it was expanding, which would facilitate the entry of new suppliers, or static, in which case the existing market leaders would fight to preserve their share.

The statistics available on trade in yeast are very poor, as yeast is too specialised a commodity to merit separate entries in most compilations of imports and exports (it has a six-figure classification in the SITC). In the trade statistics of many countries, figures for yeast are combined with those for baking powder or even submerged in the classification 'food products n.e.s.'. The only available tables which divide yeast exports into active, inactive, bakers' and seed yeast are the EEC statistics classified by the NIMEXE system(24).

These statistics show that little yeast is exported from the EEC by countries other than France, the Netherlands, the U.K. and Denmark. Of these, Denmark exports mainly to Scandinavia, whereas France, Netherlands and the U.K. house major international yeast

exporters like Lesaffre, and DCL (Yeast), who export worldwide. The exports from these three countries of active bakers' yeast are shown in figure 4.18.

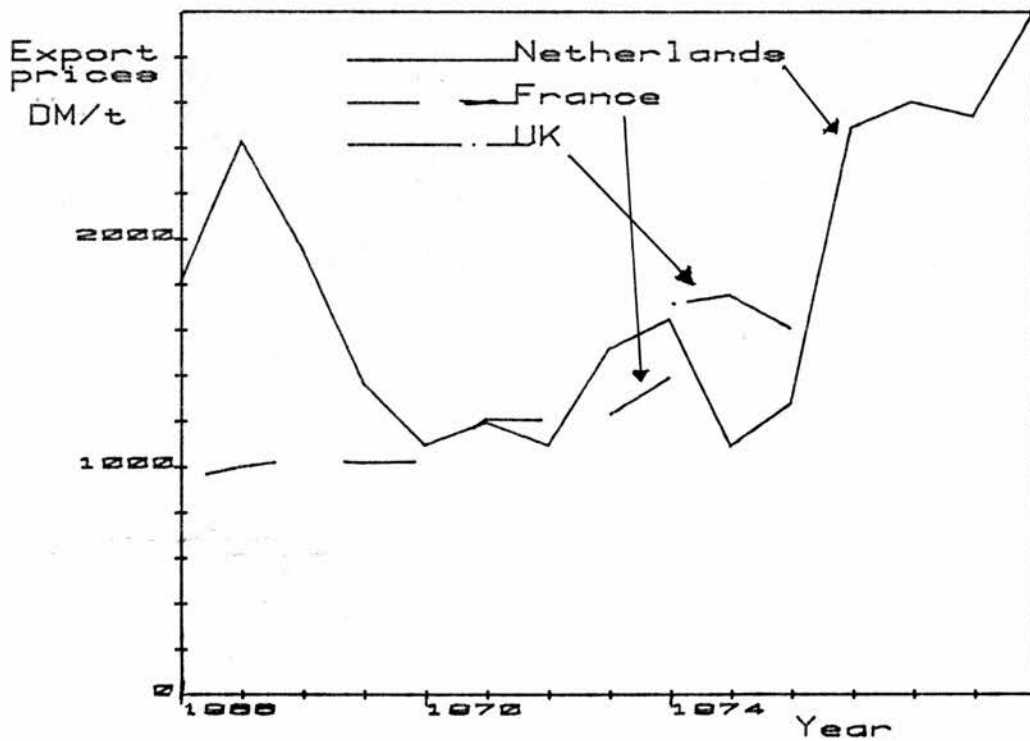
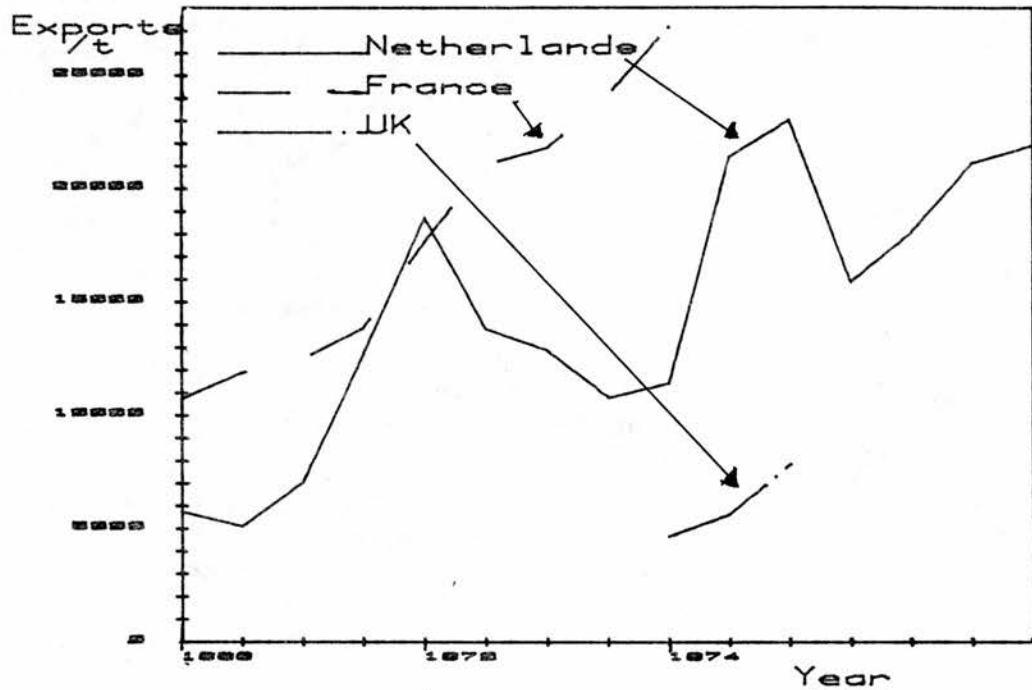
All three increased their exports between 1966 and 1980, but with periods of less rapid growth or even, in the case of the Netherlands, reductions in their level of exports. Consequently, although the markets were expanding, the severe short-term fluctuations provided an incentive to protect markets against competition.

That the market was very competitive can be seen by comparing figure 4.18 with the export prices shown in figure 4.19 (calculated from(24) in DM to reduce the effects of inflation). Reductions in the price of exports from the Netherlands corresponded to increases in their sales, and most of their price increases corresponded to sales reductions. Why the French exports and prices did not show such variations is not clear - perhaps they sold more to traditional markets, whereas the Dutch company was trying to enter new markets.

The destinations of these exports are less certain, as, in general, the EEC statistics give only the exports to other EEC members and major exports outside the EEC. The Netherlands' exports outside the EEC were all classified as 'Secret'. Only up to 1973 did France give a more or less complete breakdown of its yeast exports. Other information on the direction of trade in yeast and baking powder can be found in the UN 1976 World Trade Annual(25) which only gives the major exports from OECD countries, and in import figures for individual countries. From such incomplete statistics it is not easy to determine either the total world dried yeast or the Indian Ocean market. An independent estimate of the total world yeast production

Figures 4.18 and 4.19. Quantities and prices for yeast exports from three European countries.

(Source: Eurostat)



was 144 kt/a in 1964(26), but this included production for home consumption and pressed yeast production. To obtain an estimate of the Indian Ocean market, the exports by France in 1973 were added to those of other OECD countries in 1976, for each country around the Indian Ocean. The larger of this figure or the imports as given in the country's import statistics were added to the country totals to get an estimate for the Indian Ocean market. This came to eight thousand tonnes per annum. It can be only the very roughest guide to the Indian Ocean imports of active dried yeast, as it includes imports of baking powder and leaves out Indochina, the Indian sub-continent, some Arab states and Somalia.

Roughly speaking, Yeast Producers (Mtius) were trying to capture some 10% of this market. This would imply having to sell to many countries, as, excepting only Australia, no one country could have imported all 800 t/a. Some might use more, but in the form of locally produced pressed yeast. Nevertheless, some of the markets were substantial and worth defending - in 1973, for example, the French sold 600 t dried yeast to Indonesia, 3% of their exports outside the EEC. Such a market would be worth defending, even at the expense of temporarily selling at a loss, this loss being financed by the profits on the other 97% of sales. But for Yeast Producers (Mtius) Ltd. this market represented 75% of production capacity - they did not have the resources to meet losses on such a scale for more than a few months.

These marketing and financial advantages, together with a reduction in the proportion of overhead costs in the cost of production, for larger companies has, historically, led to an increasing centralization of the industry, exemplified by the concentration of the yeast industry in the U.K. between 1952 and 1957. To quote Willmott:(27)



There were still seven yeast factories operating in the United Kingdom, of which three were owned by D.C.L. The others were the Standard Yeast Company's new factory at Dovercourt in Essex (which had also started operating in May, 1952), the British Fermentation Products factory at Ipswich, the Tower Yeast Company in Birmingham, and the Premier Yeast Company in London. All of these factories were appreciably smaller than the D.C.L. units and as a result of agreements the last two named ceased to operate by 1957. The management of the Standard Yeast factory at Dovercourt was transferred to D.C.L. who eventually bought it in March, 1957. With the acquisition of the Dovercourt factory, and the improvements at Bristol and Glenochil, the retention of Vauxhall Yeast Factory was no longer necessary. It was, therefore, closed down in September, 1957, after continuous operation as a yeast factory for twenty-eight years.

It is interesting that the 'appreciably smaller' British Fermentation Products factory still survives as part of a large Dutch company. This suggests that the advantages of larger companies are not so much in 'economies of scale' in the cost of production, but lie, rather, in financial strength and marketing advantages.

From the foregoing, the international export dried bakers' yeast market can be characterized by the dominance of a few, large yeast producers, in competition with each other. The market has been expanding, but irregularly, encouraging these companies to defend their markets to an extent that would not be necessary in a steadily increasing market. Each company has its traditional markets where, usually, they have little competition, and others where they compete.

This makes it particularly difficult for new 'third world' producers to enter the world market as the traditional markets of any supplier tend to be heavily defended, whereas the markets in which there already is some competition offer lower returns. The new producers must have a very good competitive advantage in cost, quality or service and either a large home market or an adequate financial base to enable it to sustain heavy losses for the first few years of

market penetration.

Mauritius had a very small internal yeast market, and is not part of any regional grouping which might have provided a larger 'home' market. It had neither cheap energy, cheap labour nor cheap molasses, so Yeast Producers (Mtius) Ltd. had little prospect of competing on cost with the large semi-automated plant to European producers. It had difficulties in reaching the quality of the yeast produced by the international exporters, let alone providing a superior quality product. Its only apparent advantage was the possibility of providing a superior service to customers as deliveries only had to cross the Indian Ocean, in principle allowing more frequent shipments sent at short notice.

Such was not the case. As mentioned earlier, Mauritius is not served by regular, timetabled liner services to the countries that might have bought its yeast. World shipping routes serve 'North - South' trade between Europe and North America and the Third World, leaving 'South - South' trade to the irregular movements of tramp steamers and local shipping lines. This led to shipment to Jordan via Marseilles, Sri Lanka via Singapore and so on. Whereas the direct shipments might only take two weeks to reach Singapore, or eleven days to reach Mombassa(14), the indirect shipments took much longer, up to three months to reach Sri Lanka or Amman. Despite the efforts of Lallemand Inc., and their Mauritian shipping agents, to reduce these delays, direct shipments were rare and these indirect routes were often the only possible ones.

As a result Yeast Producers (Mauritius) Ltd. could provide no more than a relatively poor service to the customers, which led to

deterioration of yeast during transit (reducing the possibility of competing on quality), and also to high freight costs, such that it was cheaper to supply Kenya from Montreal than from Mauritius(7). It was as cheap to send yeast from Mauritius to France or the Netherlands as it was to Kenya or Singapore (see figure 4.9). Such difficulties are typical of shipping from 'sea-locked' economies.

To return to M. Hugnin's other points, concerning the traditional nature of bakers, the local agents being tied to one supplier, lack of foreign currency and corruption, apply only when selling from a distance, sitting behind a desk in Mauritius. When a company sends salesmen to visit the importers most of these obstacles can be overcome. The lack of foreign currency argument only applies when the country concerned produces yeast locally; if the people eat bread and there is no yeast then the country has to import, as Ceres Industrias Alimentares of Maputo, Moçambique did from Lallemand(3), despite a severe lack of foreign exchange. Once the style of marketing changed, upon Lallemand Inc. taking responsibility for this, such difficulties were often overcome, and the sales increased.

Why did Yeast Producers (Mtius) hope to sell yeast by these methods? Certain insights can be gained in to this by studying the local marketing of yeast in Mauritius.

No yeast was sold before May 1976 because of confusion between Yeast Producers (Mtius) Ltd., Mauritius Cold Storage and officials of the Ministry of Commerce and Industry about whether they could sell any of their production on the local market whilst being a company with an Export Enterprise Certificate. In fact, such companies are permitted to sell 10% of their production on the local market, but by

the time this had been clarified several shipments of imported yeast had arrived on the island.

Even after they had begun to sell yeast locally, they managed to capture only a small part of the market. In the financial year 1976/77 the total sales were only 18 t(2) while the yeast imports for 1976 and 1977 were 43 t and 45 t respectively(1). This led Yeast Producers (Mtius) to undertake their first local market survey in 1977(2). This survey showed that:

- i. Most yeast consumers in Mauritius were not acquainted with the local yeast.
- ii. Some bakers had already tried local yeast and thought it slow, but were well satisfied with the samples produced in 1977 using Lallemand technology.
- iii. Mauritius Cold Storage had made little effort to deliver far from Port Louis. They supplied the yeast in broken cartons, open plastic bags, from which the yeast had spilled.
- iv. Some 80% of the bakers used 'Saf levure' sold by M. A. Cassim at Rs12/kg (cf. Rs9.50/kg local yeast). This had two advantages, the bakers could buy their flour, salt and sugar in the one trip, and they obtained credit from M. Cassim.
- v. Neither Mauritius Cold Storage nor Yeast Producers (Mtius) had had any contact with the bakers or any knowledge of their problems.

The authors of this report concluded from their survey that marketing techniques of Mauritius Cold Storage left much to be

desired. They wrote:

La levure locale, n'étant qu'un des nombreux produits vendus par la Mauritius Cold Storage, n'a pas reçu, à notre avis, suffisamment de considération. Il y a eu un peu de publicité faite sur les journaux mais, malheureusement, le message n'a pas passé. Rien n'a été fait pour y remédier.

Par manque de contacts avec le consommateur, la Mauritius Cold Storage ne connaît pas les problèmes de ce dernier. Pourquoi n'utilise-t-il pas la levure locale? Quelles sont les qualités qu'il réclame? Est-ce l'activité de la levure? Est-ce une livraison régulière? Est-ce un emballage solide, attrayant, des petits logements ou des gros? Est-ce le prix? Est-ce la renommée? Est-ce les facilités de paiement? Et ceux qui utilisent notre levure pourquoi le font-ils? Est-ce le prix, la fraîcheur du produit? Autant de questions qui sont restées sans réponse à ce jour. Resultat: un fossé entre le vendeur et le client et un autre encore plus grand entre le client et le producteur local.\*

How could such a situation have arisen, and why was it allowed to continue for so long? Such commercial behaviour has often been described as due to an 'import mentality', which is supposed to reside in the heads of managers of the larger importing companies. In using the term 'mentality', this behaviour is considered irrational - yet for importers of essential goods in a heavily import-dependent economy this makes commercial sense. Most of the imports of the larger importers are of well-known products that 'sell themselves'. The com-

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\* The local yeast, being only one of numerous products sold by Mauritius Cold Storage, has not received, in our opinion, sufficient consideration. There was a little newspaper publicity but, unfortunately, the message did not get across. Nothing has been done to correct this.

Through lacking contacts with the consumer, Mauritius Cold Storage does not know their problems. Why do they not use local yeast? What properties do they require? Is it the activity of the yeast? Is it regular deliveries? Is it solid, attractive packaging in small and large sizes? Is it the price? Is it a renowned brand? Is it the payment terms? And those who use our yeast, why do they do so? Is it the price, the product freshness . . . ? So many questions which have remained without reply to this day. The result: a gap between the seller and the client and another even bigger between the client and the local producer.

pany need not spend any time or money in promoting or distributing the product, the customer bears the costs of transport and finding out when the product is in stock. Typically, an importer will be the sole agents of certain dominant brands. Thus removed from competition with other importers, there is no incentive to improve service to the customer. Instead, there are advantages to be gained by reducing service levels to cut costs. The logical conclusion is the provision of a warehouse in Port Louis where the customers come from all over the island. To further reduce their costs they can employ unskilled labour in their warehouses - if this results in torn bags of yeast, broken boxes, or other damage to the product the customer will still buy when he has no alternative.

This straightforward commercial practice of cost cutting in a guaranteed market no longer suffices when there is brand competition, between different importers, or when a new local product has to be sold. The experience of selling competing imports is not to be found in the large Franco-Mauritian importers, as very often just one of them imports a given product, or, if several do (e.g. plywood), they somehow manage to all sell at the same price and keep the same proportion of the market every year. New local products have been so few and far between( # ) that such companies have no experience in marketing them - so why should it occur to them to change their methods?

Unlike the large Franco-Mauritian importers, it is the small Sino-Mauritian or muslim companies that usually introduce competing

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# Some new local factories produce traditional products by carrying out the finishing operations on semi-finished inputs, supplied by a foreign company which used to export the finished product. Such local products merely substitute the market share of their parent company, so there are no new marketing problems.



imports. These use more dynamic marketing methods, more suitable for new local products, than the methods of the large importers. But, it does not occur to anyone in the sugar industry to sell through them. Even the authors of the Mauritian yeast market survey did not consider trying to get M.A.Cassim to act as their distributors.

Why then should Yeast Producers (Mtius) Ltd. have entrusted their local marketing to Mauritius Cold Storage, and then waited until October 1977 before carrying out a market survey? They were not, after all, an import company, so how could they suffer from an 'import mentality'?

Nirmal B. Gobin has described Mauritian companies as production-oriented rather than marketing oriented(28). The following quotes from his articles make this clear:

The production-oriented company manufactures (or imports) the product and then tries to sell it, while the marketing-oriented company first seeks to identify customer needs and then satisfy these needs by offering the right product or service. In a rapidly developing economy - such as the Mauritian economy in the years 1973-74-75 - where demand exceeds supply, the company can sell almost anything. But as an economy cools down, reduced or decreasing income makes consumers selective in their buying.

It is a known fact that already a few Mauritian industries have stopped or nearly ceased production because they are in a glut. Many companies have erected factories with the hope or hunch that they would readily sell what they would produce. And suddenly they find that the market cannot absorb their production, result: machines are stopped and capital in terms of millions of rupees are tied down, idle!

He emphasised the need for two-way communication between the company and its market, and for an integral approach to marketing, giving examples of problems which arise in a production-oriented company, such as, '... delivery of goods in unsaleable conditions to the customer by the distributor as a result of unfavourable stocking



and handling conditions '.

His typification of a production-oriented company fitted Yeast Producers (Mtius) like a glove; both in its local and export marketing. Yet, it is not enough to make an idealist comparison between a production-oriented company and a marketing-oriented one. Given the social origins of the company and its managers within the sugar industry, it was inevitable that the company became production-oriented.

The decision to set up a yeast factory was not taken as a result of Mauritian initiative. No Mauritian investor had studied the market, decided there was a particular need, and then studied how to supply this need, as Daniel Lagesse did before setting up Packaging Industries Ltd. The initiative came from a South African company, while the Mauritian company played an essentially passive role. Deep River - Beau Champ like all sugar companies, had had liquid capital, from the 1974 sugar crop, available for investment. For them it was easier to put this money into an outsiders proposal rather than search out more investment opportunities on their own.

Similarly, it was easier to ask a friend, in an allied company, to look after export sales than to start their own marketing organisation and hire a salesman to fly to the markets and talk to potential buyers. It was easier to ask a friend, in Ireland Blyth Ltd., to take care of local sales rather than set up their own sales network or even negotiate with a distributor outside the franco-mauritian community.

This last point is important - the people involved with the beginnings of the company were all within the sugar industry elite.

The selection of production and marketing managers, and of local sales agents, was done on the particularist basis of looking to friends or colleagues in the same community and, if possible, within the same financial grouping. This particularist behaviour in small island societies was described by Burton Benedict(29,30), who contrasted it to the universalist behaviour of appointment on the basis of competence. The members of the Mauritian sugar industry elite are notoriously slaves to particularist decision-making. Note, for example, the difficulties University of Mauritius sugar technology diplomates have had in obtaining employment in the sugar industry - unless they were white!

Particularist decisions taken by Deep River - Beau Champ S.E. led to the appointment of staff and agents from within sugar industry-linked companies. As all marketing of sugar and molasses is handled by the Mauritius Sugar Syndicate, the Mauritius Molasses Co. Ltd. and the Alcohol and Molasses Export & Co. Ltd., industry managers and owners have had little experience of marketing. The consequence was a production-oriented company.

In conclusion of this section on marketing, there follows a synthesis of the alternative static explanations of the difficulties encountered within a dynamic account of how Yeast Producers (Mtius) Ltd. acted on and reacted to marketing problems.

Founded by a sugar estate, it chose to employ methods and personnel from the sugar industry. This choice was natural and inevitable, given the particularist decision-making typical of the sugar oligarchy. As people within the sugar industry have had little experience of marketing, but much of production, the company was

production-oriented. Consequently, no market surveys were carried out, and the marketing function was delegated outside the company, as it was not seen as a principal concern of the company. These 'outsiders' were, in fact, also members of the same community, similarly production-oriented, and so failed to obtain many first orders. As they had no system for feedback from the customers they were not aware of the low yeast activity, which was responsible for the lack of repeat orders.

This was not perceived as a difficulty by the participants at that time (I am writing with the benefit of hindsight), although other Mauritians interviewed in 1976 had pointed out the poor returns on marketing by letter. But, when Lallemand took over the marketing they managed to obtain many new orders while facing the same external difficulties that Yeast Producers (Mtius) had. Lallemand was more of a marketing-oriented company.

Once Lallemand took over the marketing, sales were no longer limited by a lack of attention to marketing, but by the fundamental difficulties of transport and competition. The transport difficulties reduced the number of markets in which the factory could compete as deliveries to certain destinations were almost impossible, and also reduced the revenues because of high shipping charges. Competition from established companies prevented entry into certain markets (e.g. no yeast was sold to Réunion) and in some places reduced the returns as Lallemand was forced to compete on price.

Of these two, I would think that the transport problems of shipping from a 'sea-locked' country were more important, as the company losses were more sensitive to price than sales volume, and the

freight costs were 10-20% of the total value of the shipments.

Yeast factories in more favourable locations would not suffer from the same problems in shipping, but would still have difficulties in penetrating an unstably expanding market, defended by highly capitalised companies, unless these factories were partly owned by such a company or had a protected regional market.

#### **4.2. Yeast quality - transfer of production technology.**

The yeast produced at first was considered slow by Mauritian bakers(2), and had an initial baking activity of 120 mm Hg and only 70 mm Hg after eight days at 45 °C(5), whereas a good yeast can keep its activity for as long as a year in the absence of air(31).

Yet, after changes in the operating and quality control procedures, introduced after trials by Lallemand engineers and the Mauritian staff, the keeping quality of the yeast was improved so much, that by December 1977, ". . . the yeast produced was of a quality as good as the competitors'."(6) This was achieved using the original equipment installed by Anchor Yeast.

How was this achieved? M. Duvergé(6) listed the objectives of the trials under the supervision of the Lallemand consultants as follows:

- i. the elaboration of a good seed and sales fermentation schedule,
- ii. the eradication or, at least, the minimisation of infection,
- iii. a good filtration and drying procedure, and

- iv. a good quality control covering the maximum of check points during the production and especially on the finished product.

The drier operation was changed to reduce the accumulation of yeast at the bottom and, hence, the incidence of hot spots, which had led to the formation of large clumps of dead yeast cells. More salt was added before filtration, to remove more water from the cells, leading to a drier paste entering the drier.

The incidence of infections was reduced by a stricter control on the fermentations, involving many more microbiological and performance tests - 222 incubations and colony counts, 48 cell counts, 12 hours of dough and gassing power tests each week(32), instead of the 50 tests per week previously undertaken.

The result was a reduction in the proportion of reject yeast from 67% to 7%, achieved by changes in technique rather than equipment.

This clearly shows that, in dried yeast production, the technology consists of not just the fermenters, heat exchangers, centrifuges, rotary filters, driers, and pumps to be picked out of some shopping list ("choice of technology" according to Pickett et al(33) ) but includes the way in which the equipment is used, and the process managed.

Under this perspective of technology, there were two transfers of technology to the production staff of Yeast Producers (Mtius) Ltd., the first from Anchor Yeast, the second from Lallemand. Why did they have different results?

Consider three aspects of these transfers:

- i. What was the technology available to be transferred from South Africa or Canada?
- ii. What relevant knowledge and skills did the recipients possess before each transfer?
- iii. How was the transfer of knowledge, skills and technique effected?

Anchor Yeast had factories in large South African cities, where it produced active dried bakers' yeast for sale in the cities and throughout South Africa. The distances and transport facilities are such that yeast can quickly reach the consumer. The company never had to face the problem of maintaining yeast activity during long shipments, a problem faced and overcome by the established international yeast exporters.

So they had no need to produce a yeast with exceptional keeping qualities. Even if South African bakers had thought the yeast slow, they had no choice as the market was protected as a consequence of the post-war National Party policies to develop local industries(34).

The absence of commercial pressures to improve yeast quality led to a certain complacency in the South African yeast industry. So, while the factories grew bigger, and the equipment was modernised to reduce production costs (\*), the number and interpretation of quality control tests remained at the level reflected in M. Duvergé's training.

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\* Even to the extent of using tower driers, whereas rotary drum driers have been standard until very recently even in DCL factories.

In complete contrast, Lallemand Inc. was used to competing in international markets, producing yeast capable of meeting high standards even after long shipments, and knew how to reach higher standards when necessary to cope with exceptionally long delivery times.

Before the Beau Champ yeast factory was erected, no-one involved with the project knew much about the technology of yeast production. Deep River - Beau Champ had not made any detailed study of this, or any substantial effort to contact Mauritian sources of expertise, such as the MSIRI or the University of Mauritius. Although there was at least one Franco-Mauritian microbiologist on the island (#), they chose Serge Duvergé, their own factory chemist, to be trained as production manager. He learned all he knew about yeast in his five months training course in South Africa.

By the time the Lallemand consultants arrived, M. Duvergé and all the workers had substantial practical experience of running the factory, but no more theoretical understanding of how it worked.

The methods used to transfer technology differed greatly between the two companies. Anchor Yeast relied upon their training course in South Africa for the factory manager, and tried to copy in Mauritius the operation of their factories in South Africa. Their principal concern was in the erection of the equipment, so they sent three engineers to Mauritius to supervise this. Once the factory was working, after a fashion, they left and returned to South Africa. The Mauritian staff had to deal on their own with infection problems caused by the absence of an air filter in the South African company's

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# Gerald de Senneville, working in Scott & Co., dealing with imports of whisky and chocolates.



design.

When Lallemand consultants arrived in March 1977 they studied the factory operation and proposed modifications to the process. They then tested these procedures alongside the Mauritian staff until they had succeeded in improving the yeast quality. From this joint effort the Mauritian staff learned not only the technique proposed by Lallemand (which they strived to put consistently into practice between March and December), but also enough about the process to initiate their own experiments, in November, in order to increase the factory production capacity(6). That they did this, also shows their increase in self-confidence during this experimental period.

We see then, that Anchor Yeast only transferred to Mauritius a part of the technology needed to produce dried bakers' yeast. To produce a quality yeast requires not just good equipment, not just a set of instructions to follow, but a trained, confident, staff who understand why they are doing what they are doing, and a set of operating procedures developed for the particular factory (infections and overheating are more easily avoided in Montreal or Clackmannanshire than in Mauritius).

The carbon copy approach of Anchor Yeast did not provide this - it was only sufficient for the minimal objectives of Anchor Yeast, to sell the plant and get it to produce some yeast.

Lallemand, however, succeeded in completing the technology transfer by sending consultants to Mauritius who modified the process to meet the specific conditions of production and shipping in Mauritius, and trained the Mauritian staff in factory operation and factory-scale experimental techniques. This was needed to meet their

objective of guaranteeing the production of a high quality yeast, then and after they had left.

#### 4.3. Formation and financing of the company

Why did Yeast Producers (Mtius) Ltd. have such a low proportion of share to loan capital? This can be <sup>mainly</sup> put down to the failure of Anchor Yeast to take up its 49% share entitlement. To understand how this was possible, it is necessary to study the particular interests of Anchor Yeast and Deep River - Beau Champ S.E. in forming Yeast Producers (Mtius) Ltd.

In the beginning there was little interest in Mauritius in producing bakers' yeast. Although this was mentioned in the MSIRI report(35), which devoted more attention to food yeast and the production of chemicals by fermentation (ethanol and citric acid). There are only two references, by M. Paturau and other, to the production of bakers' yeast in the report. In the various articles, appearing in the Mauritian press over the years, advocating the utilization of molasses in Mauritius, little mention was made of bakers' yeast. In particular, Beau Champ S.E. had made no study of bakers' yeast production before Anchor Yeast came to Mauritius - the initiative lay completely with the South African company.

Why did Anchor Yeast come to Mauritius? This initiative does not clearly fit into the general pattern of South African investment in Mauritius. As the process of labour exploitation in South Africa changes from one of extracting absolute surplus value, from a cheap labour force of low productivity, to one of extracting an increasing relative surplus value, by increasing the productivity of each worker by some degree of mechanisation, they are encountering a shortage of

skilled workers. Although they could have employed 3.7 million workers in 1980 they would only have been able to find 1.7 million(34). One response to this has been a slight liberalization of the labour laws to allow black South Africans to work in some jobs hitherto reserved for whites. But this is limited by the resistance of white workers who provide the social base of the National Party. Thus, a more rapid solution to the needs of South African investors is to erect factories overseas making use of more abundant skilled workers who, however, are paid less than the white workers in South Africa (e.g. textile factories in Mauritius).

However, Anchor Yeast's initiative did not fit into this pattern, as the yeast factory at Beau Champ only employed 28 permanent workers, with additional casual labour for packing when needed. Such a low number of workers could readily be found in South Africa. Instead, it was forced to look overseas by other limitations on expansion in South Africa. In the cities it had to compete against pressed yeast producers, while in the countryside dried yeast was used by Africans in the preparation of alcoholic beverages as an alternative to wild yeasts, and, therefore, had to be cheap. In both markets its profitability was reduced by the increasing cost of fuels in South Africa, both for drying, and transport of molasses to the factory from the sugar-producing areas, and of yeast from factory to consumer. Trade embargoes limited the possibilities for export of yeast, so expansion had to be by diversification in South Africa or overseas (by investment or sales of technology).

Having chosen the overseas option, Anchor Yeast looked for places where a yeast factory could be erected close to a molasses source, consequently reducing the costs of transporting molasses, with at

least some consumption of yeast nearby(5). Not surprisingly, in view of the close links between the sugar industries in the two countries, the country meeting these conditions that it chose to visit was Mauritius. It was in its interest to negotiate with Mauritian companies to achieve the following:

- i. To sell its equipment and designs.
- ii. To have the possibility in sharing in any profits of the factory.
- iii. To minimise the risks in the undertaking born by Anchor Yeast.

Deep River - Beau Champ was interested in investing some of the money earned, as a result of high sugar prices in 1974, in new ventures. Naturally they were interested, if not flattered, when Anchor Yeast came to Mauritius with the proposal for a profitable sugar-linked export venture, as were others.

The directors of Deep River - Beau Champ S.E. appear to have seen this as a situation of competition between the sugar factories for the favours of Anchor Yeast. Either because of this, or through habit, they negotiated in secret, consequently isolating themselves from any Mauritian yeast expertise. Therefore, they were unable to evaluate the technical and marketing proposals of Anchor Yeast from their own resources.

This absolute technological dependence on Anchor Yeast would have weakened their negotiating position, such that the agreement reached appears to have been biased towards the South African company, in that all equipment was imported via Anchor Yeast, all technical details were decided by them (whether relevant to Mauritius or

not), and that Anchor Yeast could get away with not subscribing to the share capital of Yeast Producers (Mtius) Ltd. (Whether this was allowed in the agreement or in breach of it, Anchor Yeast succeeded, showing its dominant position.)

This shortfall in share capital was made up by loans from Deep River - Beau Champ to Yeast Producers (Mtius) Ltd. By 31 December 1977, these had reached Rs2.4 M while the company owed Rs5.8 M in other loans and a bank overdraft(3), as a result of accumulated losses. The interest payments on these were substantial, as shown in figure 4.13, and made a great difference to profitability (see figure 4.17).

#### **4.4. Cost of production - could the factory ever have become profitable?**

The final decision to cease operation, and sell the equipment, was taken on the basis of rising production costs in face of low selling prices after payments for freight and packaging(4).

From the sensitivity analyses it can be seen that both the fixed and variable costs rose from February to December 1977, as a result of changes introduced by Lallemand consultants to improve yeast quality, and cost inflation over the period. While the changes introduced by Lallemand undoubtedly improved the profitability of the company, by increasing the volume of sales, they were not enough to make the factory profitable.

While it might have been possible to reduce the production cost by concentrating on methods to save on every item, each change on its own would have had little effect, as shown in figure 4.17, and the

company did not have the time to undertake an extensive experimental programme intended to effect energy, raw material and overhead cost savings. The factory had not been designed for energy economy, as shown by the difference in steam and electricity requirements between this factory and those quoted in Paturau(10) (see figure 4.12). Even the savings of taking electricity from the sugar factory, during the season, at greatly reduced cost would not have made much difference. \*

In short, active dried bakers' yeast production turned out to be an inappropriate technology for Mauritius. This is not surprising as there was no Mauritian input into the choice or design of the technology used. No study had been made of the local yeast market, of the international market, of the Indian Ocean market, of the skills available locally, or of the possibility of starting a small pressed-yeast plant to supply the local market.

Such low-cost producers exist all over the world, using simple technologies, as shown in figure 4.20, which shows a yeast growth tank at Dhampur Sugar Mills, U.P., India. These successfully compete with imported dried bakers' yeast (such as in Maputo, where SIPAQ produces all the yeast needed by local bakers with not one worker who knows what is happening in the process).

Dried bakers' yeast production in a small country would only be economic if the factory was owned by a larger producer which could give the financial support to sustain high early losses, or there is a regional protected market where one country has been allocated the

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\* This was supposed to be illegal in that the EPZ factory was a separate company which could only buy from the CEB - but according to a Mauritian accountant there was a legal way of taking electricity from the sugar factory.



Figure 4.20  
Dhampur  
Sugar Mills,  
yeast growth  
vat.



production of yeast.

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## CHAPTER FIVE

### Rum and alcohol production in Mauritius - a traditional industry.

This chapter outlines the state of a traditional sugarcane by-product utilization industry in Mauritius, the production of alcohol, in particular cane spirit. The factories are compared with others visited by the author in India and Egypt.

#### **1. A brief history of alcohol production in Mauritius(1).**

To judge from newspaper reports, alcohol production from molasses has just been invented in Brazil. In fact, the fermentation production of alcohol from sugarcane, used to produce arrack, cane spirit or rum, often predates sugar production. In Mauritius, for a long time after the beginning of arrack production under the Dutch (around 1697), it was as important as sugar production. Before the Dutch left, they abandoned sugar production but continued to make arrack. Even in 1803, some 60 years after the re-establishment of sugar production in Mauritius, under Mahé de Labourdonnais, the revenues from 3250 t of sugar were only three times those from the 1.3 Ml of arrack. Many planters could not afford to build sugar factories, so they built distilleries.

As well as arrack, from cane juice, some rum was made from

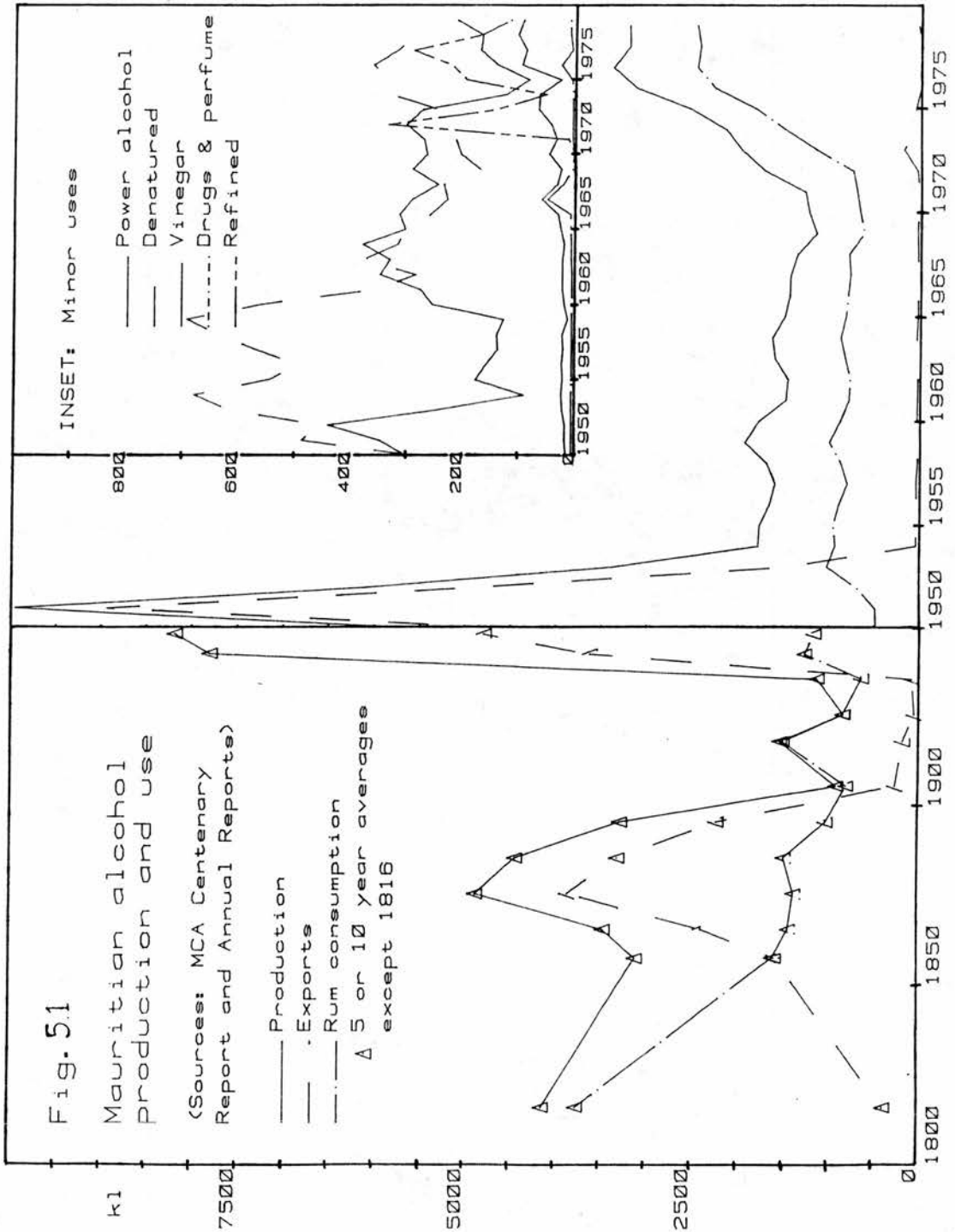
molasses. In 1744, the Villebague sugar factory produced a rum "qui jouit pendant longtemps d'une reputation coloniale". This reputation did not last long, for by the end of the eighteenth century people were complaining that it was worse than Jamaican rums. Charpentier de Cossigny found that it contained lead, from the distilling equipment. Complaints about the quality of the rum continued up to the present day; but, now, the problem is a lack of impurities rather than an excess. The wort is distilled to 95-96.5% ethanol, thus removing the desirable impurities which give West Indian rums their flavour, before being diluted and bottled with flavourings. With the exceptions of Gilbeys' Green Island Rum and Médine's Vieux Rhum, none is aged, so, strictly, these are cane spirits rather than rums.

By the time the British captured Mauritius, in 1816, 80 distilleries were producing 4 Ml each year, i.e 39 l/head! With British encouragement sugar production increased ten-fold in the next 13 years. The planters turned away from spirit production (down by 10% over this period) as they noticed the disastrous effects of rum on the slave population (such as not working hard enough). Baron d'Unienville, one of the leaders of a campaign to continue the slave trade to Mauritius, said that rum production should be abandoned.

Figure 5.2 Number of distilleries in Mauritius 1855-1981

Year	No.	Year	No.	Year	No.
1855	16	1910	6	1950	9
1860	18	1920	5	1952	9
1870	14	1930	6	1977*	4
1880	21	1940	6	1981*	4
1900	9	1945	12		

Source: MCA Centenary Report(2) and personal observation (\*)



The local consumption continued to decline, so much so that of the 109 distilleries operating in 1829 only 22 were left in 1858 (see figure 5.2). Nevertheless, during this period exports increased greatly (see figure 5.1), so that the production in 1858 was the same as in 1829. These exports, mostly to Madagascar, reached 3 Ml in 1870 and continued at between 3 and 4.5 Ml/a up to 1895, when the French conquered Madagascar. They banned imports of rum into the island, because of its effects on the local population - especially those working for French companies. Consequently, Mauritian exports dropped to 0.5 Ml/a, mostly to the Seychelles, Aden, East Africa and the UK. As freight rates changed, favouring West Indian rum, the UK sales dropped until they ended in 1920 when the British government put a high duty on Mauritian rum.

At this time molasses began to be exported, increasing 13-fold between 1885 and 1897, and also was used more as a fertilizer. So the production costs of rum increased greatly, especially as the industrial yield, in 1911, was only 30% of the theoretical yield. Furthermore, the excise duty was raised from Rs0.96/l to Rs1.67/l, which gave rise to a drop in the local consumption of taxed spirits, to 447 kl, and a great increase in illicit distillation. Little more was exported until the Second World War, when large quantities of distilled cane spirit (at 95-96.5%) were exported for blending with gin and other spirits for the troops. This continued after the war, reaching 9 Ml in 1951, but declined to 28 kl in 1954 when Britain could again produce enough alcohol on its own.

The other wartime development in this industry was the production of power alcohol for blending with motor spirit. This was not the first use of alcohol to fuel motor vehicles in Mauritius. In the

early 1930's Eduoard Langlois and Phillipe Fayd'herbe produced, at St. Antoine distillery, a motor fuel called "Cernite", made up of 30% ether, 64% ethanol (at 95-96.5 °G.L.), and 6% motor spirit. While the price of petrol was high (Rs0.39/l) they sold all the Cernite they could produce. When petrol prices came down they had to abandon production.

From 1932 Adrien Wiehe, and numerous sugar technicians, supported the production of anhydrous alcohol for blending with motor spirit - but the distillery owners did not follow this up (a pattern often repeated). However, in February 1939 the colonial government was contemplating producing power alcohol as a state enterprise, to assist their policy of making Mauritius more self-sufficient in food and other essential commodities. The Chamber of Agriculture officially wrote to the Governor, stating that certain factory owners were prepared to produce anhydrous alcohol and that the government would have to make the use of anhydrous alcohol compulsory(3). The Governor replied to the effect that he would not object to them producing absolute alcohol but "the manufacture alone of anhydrous alcohol for the purpose of replacing 20% of the imported petrol would hardly justify the exercise of the compulsion necessary to oblige the public to mix 20% of alcohol with their petrol". It appears that he thought that the alcohol would be supplied separately from the petrol and customers would mix the two in their tanks (as with two-stroke oil).\* The factory owners then offered to set up a plant if the government would guarantee a minimum price of Rs0.60/gal. The government indicated that this was too high and dropped the project in

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\* Even today, I have spoken with Mauritians who thought this, and did not realise that the petrol and alcohol would be mixed before they get to the pump.

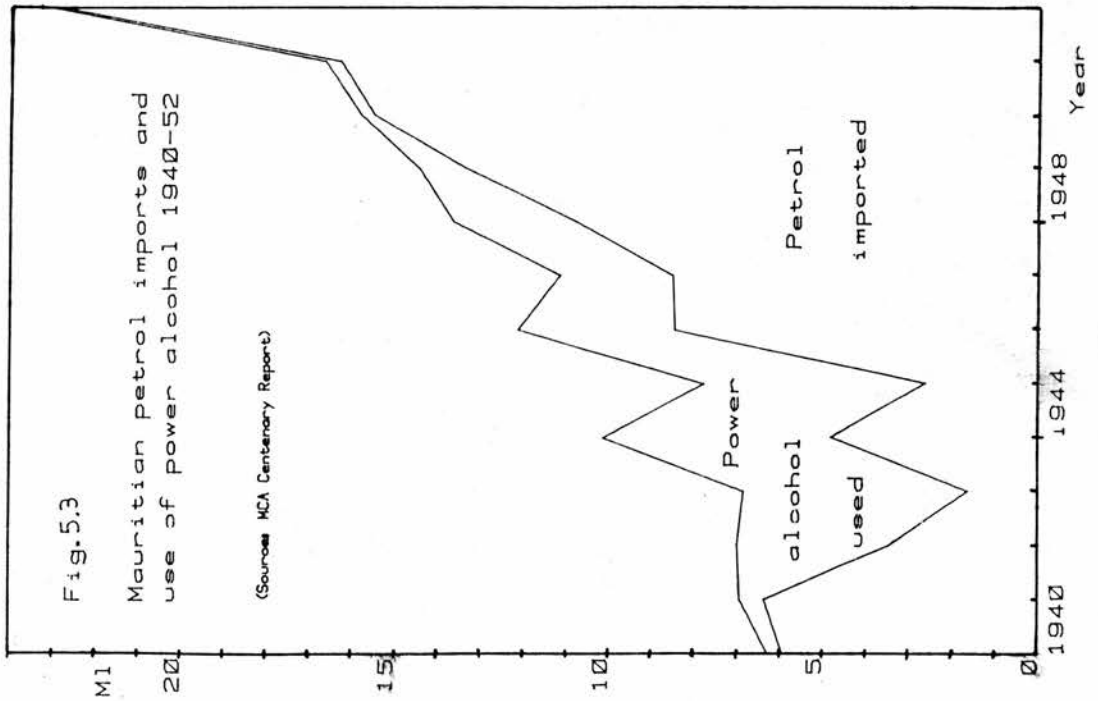
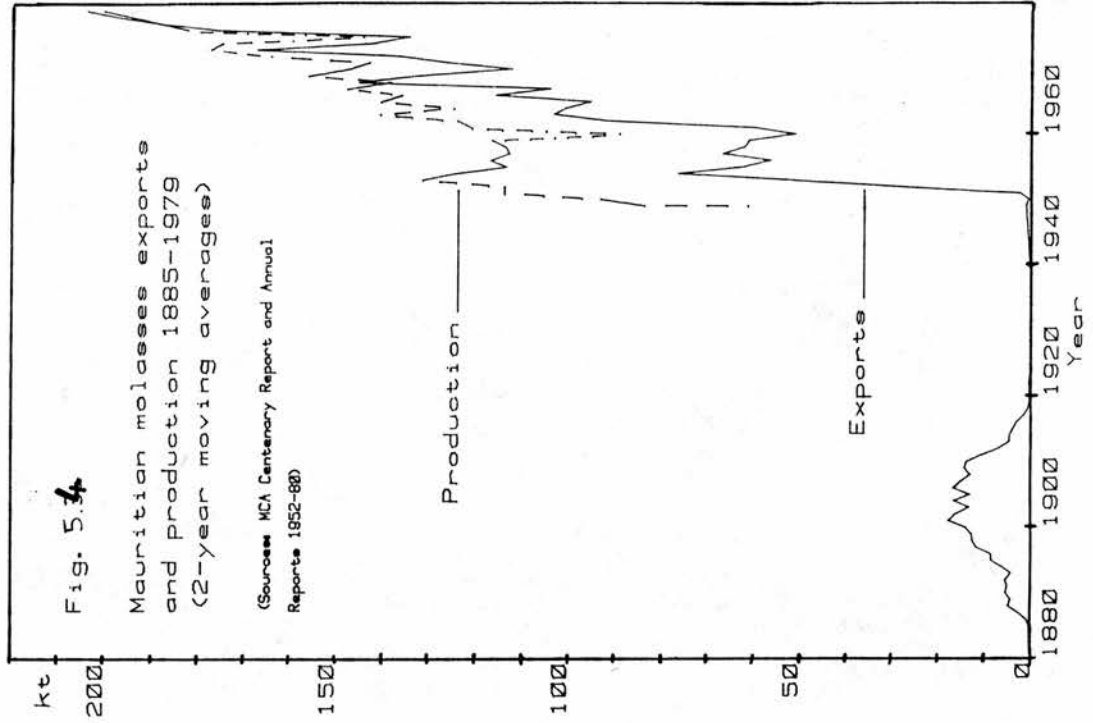


August 1939, just before the start of the Second World War. (This bears comparison with some of the statements on cheap energy made just before the OPEC oil embargo in 1974).

During the war, petrol was in such short supply that high proof alcohol with 10-20% petrol, known as "carburant", was used as a motor fuel. The government requisitioned the molasses to be fermented in eight new distilleries which were specially built for this purpose. Over 50 Ml/a ethanol were used for carburant in 1943-5. As petrol became available after the war the fuel alcohol use declined to 0.3 Ml/a. The consumption of fuel alcohol and petrol is shown in figure 5.3.

Of the eight distilleries built during the war, five were built entirely of materials which could be found on the island. Much of the equipment in the three Mauritian owned distilleries now operating dates from this time, although the St. Antoine distillery was originally built in 1900, and Médine in 1926.

The idea of producing anhydrous alcohol was studied by various committees, including the Power Alcohol Sub-committee (1944-7) and a government ad hoc committee in 1949. The latter suggested that anhydrous alcohol could be manufactured locally for less than the imported petrol cost and blended with petrol in the ratio of 25 parts alcohol to 75 parts petrol. The market would be 3 Ml/a if it were compulsorily added to petrol. From distillers figures, submitted to the government in January 1951, it seemed that it would cost Rs0.45 to produce one litre of anhydrous ethanol from rectified spirit at Rs0.35, with an estimated capital expenditure of Rs450 000. This put the production cost at the same as the selling price (no profit to



the redistillation plant) and assumed a molasses price of Rs30/ton. As the world molasses price was then Rs85/ton the plan was postponed until "economic conditions returned to normal". They never did, and as figure 5.4 shows, the proportion of molasses exported continued to rise. Meanwhile, the production of alcohol declined and the number of distilleries also declined to the present day figure of four distilleries (see figure 5.2).

## 2. Technology

The following description<sup>is</sup> of the production of ethanol for use in spirits as practiced in Mauritius, Egypt and India in 1977. The production of alcohol for use as a fuel has been discussed in the literature review.

Comparative data on distilleries visited by the writer (the three Mauritian distilleries which fermented molasses\*, Médine, St. Antoine and the O.K. Distillery at Solitude sugar factory\*\*, Panipat Cooperative Distillery Ltd. in Haryana, India, and the Hawamdieh Distillery of the Egyptian Sugar and Distillation Company) are given in figure 5.5.

To help in understanding the following account of the processes used in the Mauritian distilleries, a flow sheet, based on that used at Médine distillery, is provided in figure 5.6. This diagram also gives a partial mass balance for the process, showing the inputs and outputs corresponding to the use of one tonne of molasses. Steam and cooling water usage have not been included in the diagram, nor have

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\* Gilbeys' distillery at Plaine Lauzun uses 76% alcohol bought from the three Mauritian-owned distilleries.

\*\* Since closed down and replaced by a new distillery next to Beau Plan sugar factory.

Figure 5.5 Data on some typical Third World distilleries.

Country: Distillery:	Médine	Mauritius St. Antoine	O.K. (Solitude)	India Panipat	Egypt Hawamdieh
<b>Molasses analysis</b>	1976	1976	1976 (a)		
Sucrose	31.01%	32.32%	30.40%		33.7-40.2% (b)
Reduc. sugars	18.25%	15.12%	19.50%		14.5-17.2% (b)
Total sugars	49.26%	47.44%	49.90%		50.0-55.0% (b)
Non-fermentable sugars	?	5%(est.)	?		3.5-5.0% (b)
<b>Wort analysis</b>					
Molasses	s. g. 1.090, ~17-21%				
-sugars	8-10%				
-sucrose	5.2-5.6%				
-invert	3.3-3.7%				
Ammonium sulphate	194 ppm w/v	842 ppm w/v		320-500 ppm w/v	Use urea and Amm. phosphate
HF	57 ppm w/v	600 ppm v/v			
Sulphuric acid	1300 ppm v/v				
Fermentation conditions					
Temperature(°C)-winter	25	38	33	31	33
-summer	35	4.8	40	40	38
pH	4.5			4.6-4.8(yeast growth) 4.0-4.3(fermentation)	4.5
%EtOH in beer (v/v)	6			6-7 (c)	
<b>Columns</b>					
1st				20 plates at 480 mm	
2nd				46 plates at 150 mm	
3rd				10 kl pot still	
<b>By-products</b>					
Yeast					1465 t/a (g)
Heads	10% on EtOH			Used as denaturant	
Fusel oil	1% (at 88%) on EtOH			Used in pharm. & chems.	355 ppm on EtOH (g)
Vinasse	pH 4	pH 4	pH4	3.5-4.5% 800 red. to 0.3%	1-1.5% red. sugars (b)
-treatment	bagasse compost	none	irrigation/none	in anaerobic lagoons with ammonifying bacteria	1500 m <sup>3</sup> /d, (b) untreated (b)
<b>Yield</b>					
T EtOH/t molasses	220	196	215-20	225 (c)	237
% theoretical	74(d)	69(d)	72-73 (d)		80
<b>Production</b>					
1971		240 kl			
1973		326 kl			
1975		625 kl		14 kl/d	All Egypt: 25 Ml 30 Ml
1976(expected)	800-1000 kl	555 kl	850 kl	300	600 (g) US\$ 100 (g) US\$ 0.24 (g)
<b>Economics</b>					
Employment		All distilleries 196 (e)			
Average monthly wage		US\$ 140 (e)			
Wage cost / l EtOH		US\$ 0.10 (e)			
Prodn. cost / l EtOH		US\$ 0.29 (f)			
Selling price / l EtOH		US\$ 0.45 (in 1976)		US\$ 0.06 US\$ 0.08-0.10 (c)	
<p>(a) Highest sugars in North for 1976 (Beau Champ factory). 1976 Source: MSRI Annual Report 1976(4).</p> <p>(b) Source: Madi(5).</p> <p>(c) Data for all India from Sharma(6).</p> <p>(d) Calculated assuming 5% non-fermentable sugars.</p> <p>(e) Calculated from survey of Employment and Earnings, Sept. 1978(7).</p> <p>(f) Source: Antoine(8).</p> <p>(g) Pers. comm. Alpine. Source for all other data: pers. comms. during visits.</p>					

Figure 5.5 Data on some typical Third World distilleries.

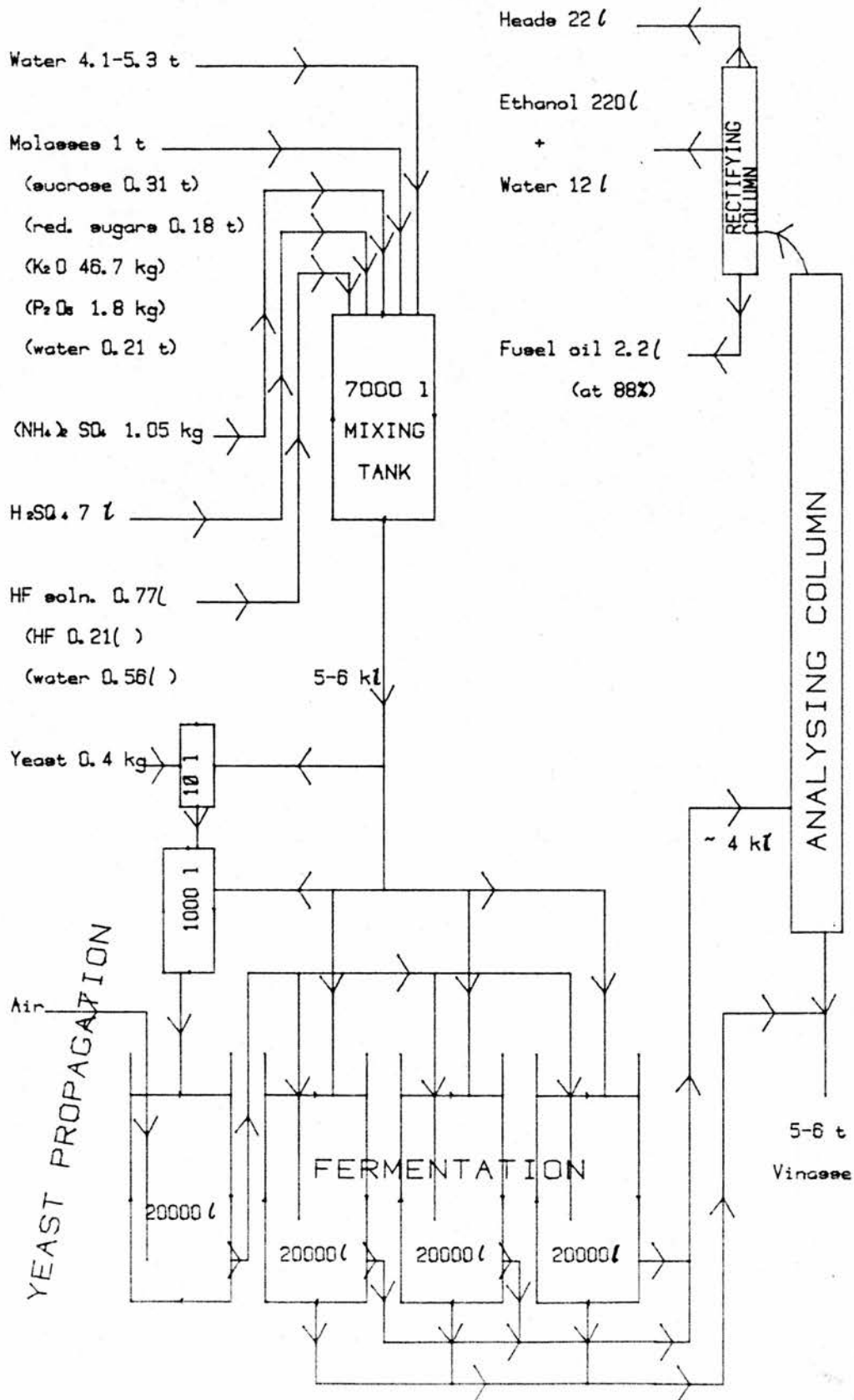
all the process water flows (e.g. evaporation from the open fermentation vats).

The three Mauritian distilleries used equipment which was put together in the Second World War. They took molasses, diluted it about four times to produce a wort containing 8-10% fermentable sugars, added some ammonium sulphate and some sulphuric acid to reduce the pH (so reducing the chances of infection). They bought packets of ordinary dried bakers' yeast, which was then grown aerobically on the wort up 40 l, then to 1000 l and then 20 000 l in the 'mother' tank. One third of this yeast inoculum was drawn off into another tank, where it was filled with more wort and left until the alcoholic fermentation was complete. This took place in open tanks, cooled by water sprayed down the outside of the tanks. This is not a very good cooling method, and the fermentation temperature reached 40 °C in the summer at both Solitude and St. Antoine distilleries.

When the fermentation was complete, and the wort contained up to 6% alcohol, the contents of the tank (including the yeast) were pumped to the distillation column (or analyser). This was operated to produce either an 86% ethanol solution, which was fed to the rectifying column, or a 76% solution, which was sold to the Gilbeys' distillery (for rectification to produce high quality spirits). The rectifying column produced 94-95% ethanol, plus heads (10% of the quantity of ethanol produced), plus fusel oil (1% of the ethanol produced).

Most alcohol produced in Mauritius is diluted to 40%, flavoured and sold as cane spirit. This market is shared equally between the distilleries (which are all operating at below capacity). O. K. distillery at Solitude put some through a third column to purify the

Figure 5.6 Flow chart for a Mauritian distillery.



alcohol to 96-96.5% while reducing impurities other than water. This is used in the production of their higher quality cane spirits, Ricard, and perfumes (using imported essences), while some is exported. ~~Now~~ Now the distillery at Solitude has been replaced by a new one, at Beau Plan, which can produce more high quality alcohol for export. Médine distillery also uses a little of its alcohol for vinegar production. Gilbeys distil the 76% ethanol, <sup>which</sup> they buy from the other distilleries, to produce 96.6-96.8% alcohol (in a Gruman Herme column). This is used for their three kinds of cane spirit and gin production (using an old pot still, shown in figure 5.7). They also produce matured rum, leaving the 76% spirit in old sherry barrels for 5 years. White rum is made by passing the matured rum through charcoal columns.

Figure 5.7  
Gin still  
used at Gil-  
beys, Mauri-  
tius. (Its  
manufactur-  
ers ceased  
trading in  
1936.)



A little alcohol is denatured as follows:

White power alcohol -

To 94-95% ethanol add 2% of pyridine and 2% of motor spirit. (This is used nowadays for varnish rather than



motor fuel.)

Heating and lighting spirits - To 87-88% ethanol add 0.5% of pyridine, 0.5% of paraffin and 0.05% of methyl violet.

Blue spirit - Made from the heads (much of this is methanol) and fusel oil. (Used as a cheaper alternative for alcohol lamps and stoves. Disliked because of the smoke and smell it produces.)

The Panipat distillery is a 15 000 l/day (at 94-95% ethanol) distillery <sup>situated</sup> north of Delhi in Haryana state. They produce country liquor, "whisky", several kinds of cane spirit and rum, and some industrial alcohol (10% of production). The molasses and water are blended in a steam heated column which can sterilise the wort, if necessary. This is done to the wort used in the first stages of yeast propagation, up to 2000 l. As can be seen from figure 5.5, they adjust the pH and ammonium sulphate additions separately for optimum yeast growth and optimum alcoholic fermentation. The final stages of yeast growth and the fermentations take place in unsterilised open vats (up to 51 kl), so temperature control is as difficult as in Mauritius - it can reach 40 °C in summer (the optimum for their yeast is 30-32 °C).

The beer is then distilled and rectified and, for final purification, it is redistilled in a 10 000 l pot still. The usual quantities of by-products are produced. The heads are used to denature industrial alcohol and the fusel oil is sold to pharmaceutical and chemical companies.

At Hawamdieh-Giza, in Egypt, there is a much larger industrial alcohol distillery producing 25 Ml ethanol annually from 110 000 t molasses. Originally built in 1949 it has been expanded to improve yields and recover by-products.

Egyptian molasses are richer in sugars than Mauritian molasses, and so are a better fermentation feedstock. Also advantageous for fermentation is the high biotin content of 609 ppm(5), compared to a typical 1-3 ppm for cane molasses(9). Biotin is an essential yeast nutrient(10).

The molasses were partially clarified by centrifugation before dilution and the addition of urea and ammonium phosphate. Despite this clarification there were still problems of scaling in the distillation columns, which had to be cleaned periodically with a water jet. This was because the scales were due to the formation of calcium sulphate salts (74.9% of the scale weight)(5). The build-up of deposits could be reduced by the addition of descalers (e.g. "Fabkron" at 25 ppm) although this was expensive.

At a more modern distillery, in the south of Egypt, sulphuric acid clarification was practised. The molasses were diluted to 40-42 °Brix, superphosphate and ammonium sulphate were added, in the quantities necessary for fermentation, and sulphuric acid to pH 4.5. This mixture was held at 95 °C for one hour, allowed to settle for two hours and then centrifuged. This resulted in a decrease of 65% in the calcium content and an increase of 3% in fermentation efficiency, against losses of 0.3-0.5% in clarification. The scale then had to be removed only every 200 days instead of every 15 to 45 days(5).

At Hawamdieh the fermentation was carried out in covered steel

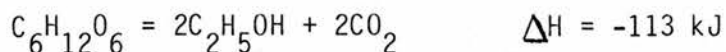
tanks - covered to reduce the chance of infections and to collect the carbon dioxide produced. The spray-ring water cooling on the outside of the tanks was inadequate at times in the summer when the fermentation tanks reached temperatures of 37-39 °C. The optimum temperature for the yeast used (their own strain, adapted to high temperatures) was 33-34 °C.

The fermented wort, or beer, was centrifuged to separate the yeast (used for fodder), and then distilled to produce industrial alcohol at 90 or 95%. 1200 l/day of the alcohol produced was fermented to acetic acid on site. The company also owns two perfumeries and an ethyl acetate plant, in which plants they use some 3.6 Ml/a of alcohol. The rest of the alcohol produced by all their distilleries is used as follows(5) :

- i. 9 Ml/a for alcoholic beverages, chemical and pharmaceutical industries, hospitals and laboratories.
- ii. 3 Ml/a of 95% and 90% specially denatured alcohol are used in solvents and chemical compounding.
- iii. 14 Ml/a of 90% completely denatured alcohol are used for heating and lighting.
- iv. A surplus of 10-15 Ml/a was available for export at 95% for beverages or in exchange for petrochemicals.

## **2.1. Alcohol production efficiency**

Looking at the efficiencies shown in figure 5.5 it can be seen that the yields of the Mauritian distilleries were only about 70% of the theoretical yield according to the equation of Gay-Lussac:



applied to the sucrose and reducing sugars in the molasses and assuming a non-fermentable sugars concentration of 5%. This compares with 80% in the Egyptian plant and over 90% in the most modern distilleries. The Mauritian yield is the same as it was when René Leclézio wrote his article on the history of the Mauritian sugar industry(1). This is not surprising, as the distilleries in 1977 were substantially the same as they were in 1957. After a French student working at MSIRI (M. Leveque) had shown that adding ammonium sulphate to the wort improved yields, that hydrofluoric acid had no effect, and that fodder yeast could be cultivated on vinasse(11,12), some of the factories had started adding ammonium sulphate and two were experimenting with yeast recovery, by centrifuge, before distillation(11) These were all the changes made to the fermentation technology by 1977, while no changes in distillation equipment had been made, except at the Solitude distillery where a third stage had been added and improved so that it could produce extra fine alcohol for use in blending spirits such as Ricard(13).

Some of the factors responsible for the lower yield were:

- i. The molasses were not clarified.
- ii. No yeast was recycled. This would save on the molasses sugars used for yeast growth under aerobic conditions.
- iii. The fermentation vats were open, allowing easy infection by wild yeasts blown from the cane fields.
- iv. The yeast was ordinary dried bakers yeast, a strain selected for high initial activity rather than prolonged fermentation

activity, or a high tolerance to alcohol, to sugars or to high fermentation temperatures.

Compare this with the practice in the Hawamdieh distillery, where a special strain of yeast was used, adapted to high fermentation temperatures and the molasses were clarified, or at Panipat, where different wort compositions and pH were used for the yeast growth and fermentation in order to optimize yields.

So these three Mauritian distilleries (Médine, Solitude and St. Antoine) were not technically optimised for the production of industrial alcohol. Perhaps they were better suited to the production of high quality rums, with considerations of flavour being more important than the yield of ethanol. But, in fact, the cane spirit produced is not of a high quality and it has to be distilled to 95% to remove some of the off flavours, then diluted and mixed with other flavours before bottling. Mauritians add dried fruits to the cheaper cane spirits to disguise other less pleasant flavours (when celebrating New Year, for example). This does not result from the composition of Mauritian molasses being greatly different from that in other rum producing countries, as is shown by an experiment under the Mauritius-Réunion Agricultural Collaboration Committee in June 1953(3). Mauritian molasses were fermented and distilled in Réunion, and produced a rum comparable to a high quality Réunion rum. In the experiment, the rum was distilled to 62% to keep the cogeners which contribute to the flavour, while in Mauritius it could be said that the cane spirit is rescued from a bad fermentation by distillation to a high alcohol concentration. No special yeast mixtures were used in Mauritius to produce these cogeners, rather accidental mixtures of bakers yeast and wild yeasts from occasional infections.

From the foregoing we can see that the lower Mauritian yield was not due to any attempt to retain flavours in their rum (as in Jamaica, where pot stills are used for this reason or in the Gilbeys' distillery in Mauritius for gin distillation). To understand why this yield was the same in 1977 as it was in the 1950s one has to look for explanations that are not purely technical.

## 2.2. "Wastes" of alcohol production.

These are the carbon dioxide produced in the fermentation, the slops from the fermentation tanks, the aqueous residue from the distillation (the vinasse), the more volatile components of the distillation which come off above the ethanol (the heads), and the fusel oil which separates out in the rectifying column.

Among the five distilleries studied, only at Hawamdieh was the carbon dioxide recovered(5). The carbon dioxide was collected, washed to remove impurities (mainly acetaldehyde and butyraldehyde), scrubbed in potassium permanganate solution, passed through activated charcoal towers, liquefied under pressure and bottled in 20 kg cylinders(14). The plant was supplied by Whittemann and Haselberg of Buffalo, New York, and needed four workers per shift, plus two extra in the morning for loading(14). They produced 3134 t in 1976, which production was limited only by the market and the liquefaction equipment (capacity 10-12 t/d), as the factory was producing about 17 kt/a.\*

A full description of such a plant is given in an article at the 17th ISSCT congress in Manila(15). A plant designed to recover

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\* Based on 16 kg carbon dioxide per 100 kg molasses, from Paturau, p.182(9)

24 t/d of carbon dioxide was installed at the Central Azucarera Don Pedro in the Philippines. The equipment, installation and building costs came to P6.5 M, while the income from carbon dioxide sales were P18 k per 24 hours operation (at May 1979 prices). It uses about 300 kW of electrical power and 37 m<sup>3</sup>/d of washing water (for removing alcohol and other impurities). The gas is collected from the fermentation vats, passes through polyethylene tubing to a water separator, a fan, an alcohol recovery column, a water scrubber, two stages of compression with intermediate cooling, activated carbon and desiccant columns, and a heat exchanger to reduce the temperature to -19 °C, whereupon the carbon dioxide liquefies under a pressure 1.96 MPa. Gaseous impurities are vented through the back of the liquefier. The liquid carbon dioxide is mostly pumped to road tankers for bulk transport, while some is loaded into cylinders. No equipment for producing solid carbon dioxide ("dry ice") by the expansion of the cold gas to atmospheric pressure is mentioned in the article, so it can be assumed that this transformation is carried out by the users.

Problems mentioned in the article include that of obtaining a consistent gas supply from the fermentation tanks, foam or air entering the recovery system, vibration and specifying the optimum operating conditions and maintenance schedules. As described in the article the result was:

To date, Central Don Pedro's liquid CO<sub>2</sub> recovery plant has performed creditably for over a year. This was due mainly to the regular and periodic maintenance jobs we have adopted like leak tests in fermentation, valve and strainer/filter checks and equipment performance tests in the CO<sub>2</sub> plant, etc. We have started this unique (sic) venture here and we hope that it persists in giant stride.

It is perhaps the relative complexity and difficulty of maintenance of this equipment (compared to that in a simple distillery)



that has discouraged other ethanol producers from collecting the  $\text{CO}_2$  formed during the fermentation. At the Mauritian distilleries, and at Panipat, the gas is allowed to escape. In fact, on Mauritius not only did the three distilleries lose a potentially recoverable 2400 t of  $\text{CO}_2$  per year,\*\* but, in 1977, no attempt was made at the brewery to collect it. Yet the same company which owns Mauritius Breweries Ltd. owns Gaz Carbonique Ltd., where 360 t/a  $\text{CO}_2$  are produced by burning oil. This they sell to the companies which bottle soft drinks.

### 2.2.1 Heads

This fraction from the distillation is used as an alcohol denaturant in some places because of its methanol content. This occurs at Panipat Cooperative Distilleries, whereas in Mauritius the heads are mixed with fusel oil to make a cheap, smoky, fuel. It is interesting to note that methanol imports into Mauritius have recently increased from 750 kg/a (average 1969-73), to 3727 kg/a in 1974, and to 5404 kg/a over 1976-7.

### 2.2.2 Fusel oil

This is a mixture of alcohols with boiling points between 80 °C and 160 °C, mainly amyl, isoamyl, isobutyl and n-propyl alcohol. It is often used as a solvent for lacquers or resins(16,17), and in India is in demand from pharmaceutical and chemical companies. In Egypt it is used as a lacquer solvent and for the evaluation of fats(5). It can command a high price where local chemical companies can make use of it, but, in Mauritius, it is merely blended with the

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\*\* Calculated from the ethanol production, the yields on molasses in figure 5.5 and the ratios of  $\text{CO}_2$  collectable to ethanol produced in Paturau, p.182(9).

heads to make cheap "blue spirit".

### 2.2.3 Yeast

During fermentation some yeast grows. This may be separated before distillation for reuse, or for use as a source of yeast hydrolysates (e.g. "Marmite") or animal feed. In many small distilleries the yeast is not separated and the wort, containing suspended yeast, is pumped to the analysing column. There the yeast breaks down, increasing the organic matter loading in the vinasse, to which is added the slops from the fermentation tanks (also containing yeast). Such a practice also increases scaling in the columns. Nevertheless, to save on the capital costs of centrifuges, many distillers are prepared to accept these disadvantages. Such was the case at the St. Antoine, Médine, Solitude and Panipat distilleries.

At Hawamdieh it had been planned, in 1967, to modify the process to produce ethanol and fodder yeast in a single process - the Vogelbusch process(5). The diluted molasses were not treated with sulphuric acid but just partially clarified by centrifuge. The fermentation was operated with partial aeration and added nutrients. Afterwards, the yeast was separated in centrifugal separators, washed and drum-dried. The drying both improved the keeping quality of the yeast and broke open the cell walls, making the nutrients available for animal digestion. It was intended to produce fodder yeast with 50% protein.

Thus, 100 kg of monosaccharides would produce 53.5 l of 100% ethanol and 7.6 kg of fodder yeast at 90% dry matter and 50% protein. This is based on 14 hour fermentations using ammonium phosphate, superphosphate and urea fertilization. The yeast production is some

2.5-3 kt/a.

As there were difficulties in obtaining 50% protein in their strain of Saccharomyces cerevisiae, unless more nutrients were used, the process was modified to produce yeast containing 40% protein as this was the most economical process.

In Mauritius, however, none of the distilleries practised yeast recovery in 1976, although experiments had been carried out at the Mauritius Sugar Industry Research Institute and at Solitude distillery(12). Leveque carried out these experiments with a Westfalia SAOH 205 centrifuge. On a 200 l sample of the "beer" at Solitude distillery 1306.0 g dry matter were recovered. If the alcoholic strength were 5%, this is equivalent to  $130 \text{ kg/m}^3$  alcohol. This particular centrifuge was not very efficient, recovering only 65% of the dry matter (according to other experiments of Leveque). So he estimated a recovery of  $160 \text{ kg/m}^3$  with a more efficient centrifuge. At Solitude this would have come to 1.2-1.3 t/d of yeast.

These experiments were made in October 1974. Yet, in January 1977 none of the Mauritian distilleries were separating the yeast produced. Only Mauritius Breweries Ltd. were separating yeast from the beer they produced, since they were producing clear lagers which have to be filtered, and pasteurized, less the beer spoils from yeast autolysis or bacterial infection at tropical temperatures. They used a small drum drier to break up the yeast cell walls and sold the yeast, together with the spent grains, to pig rearers, the Ministry of Agriculture and to Rodrigues at Rs 1.2/kg

Only recently have the distilleries in Mauritius taken any great interest in yeast recovery. Before the Solitude distillery was closed,

a double separation process was installed which recovered up to 10 kg dry yeast per m<sup>3</sup> of alcohol produced(18). In the new O.K. Distillery, at Beau Plan, the yeast is separated using a solids ejecting centrifuge, stored at 5 °C for re-use, and the excess dried for use as fodder(19).

#### **2.2.4 Vinasse use and abuse.**

In this section will be described the approaches to vinasse disposal current in 1976/7, at the distilleries visited. Detailed discussion of other alternatives can be found in the section dealing with power alcohol distilleries.

Vinasse is the name given to the residue from the distillation of the products of the alcoholic fermentation of molasses or sugarcane or sugarbeet juice. It is often mixed with the slops from the fermentation tanks, this mixture being called slops or (mixed) vinasse. It is acid (as a result of the acid added to maintain a low pH during fermentation), is highly loaded with organic matter (from yeast breakdown in the column when not separated, and from unfermentable organic matter in the molasses). At Panipat distillery the biological oxygen demand (BOD) was 35 000 to 45 000 ppm. Some typical analyses are shown in figure 5.8, while figure 5.9 compares the typical polluting characteristics of vinasse and tank slops with the Réunion standards for disposal in rivers and the sea.

Despite this high polluting load, a very common method of vinasse "treatment" is to dispose of it in a river or the sea. At Hawamdieh distillery the vinasse was discharged to a sewer, known to geographers as the River Nile. One of the Mauritian distilleries put its vinasse into a volcanic cave, supposedly watertight. (But the

Figure 5.8 Analyses of vinasse from molasses distilleries.

Concentrations in kg/m <sup>2</sup>	Sources and countries:				
	Auneau Réunion	Brasil	Gloria Brasil	Branco Brasil	Chatterjee India
Dry matter	110.75	-	-	81.5	90-110
Organic matter	85.15	42.9	63.4	60.0	-
Reducing subs.	-	-	-	9.5	10-12
COD	-	-	-	65.0	-
BOD	-	-	-	25.0	-
Fixed ash	25.60	-	-	21.5	30-40
N	1.42	1.06	1.18	1.2	1.2-2.0
P <sub>2</sub> O <sub>5</sub>	0.35	0.11	0.15	0.2	0.2-0.5
K <sub>2</sub> O	10.80	5.42	7.83	7.8	7.0-12.0
CaO	1.90	2.29	3.64	3.6	2.0-5.0
MgO	-	1.01	0.99	1.0	3.0-4.0
SO <sub>4</sub>	-	-	6.40	6.4	8.0-8.5
C	-	-	19.20	18.2	-
NaCl	-	-	-	3.0	4.5-6.0
SiO <sub>2</sub>	-	-	-	-	1-1.5
Al <sub>2</sub> O <sub>3</sub> + Fe <sub>2</sub> O <sub>3</sub>	-	-	-	-	0.4-0.5
Density	1.044	-	-	-	1.02
°Brix	-	-	-	-	8.5-10.5
pH	4.0-4.2	4.0	-	4.5	4.2-5.0

Sources: Auneau(18), Branco(20), Chatterjee(21) quoted in Patil and Jadhav(22).

Figure 5.9 Vinasse pollution load.

	Vinasse	Tank slops	Disposal regulations: To the sea Elsewhere	
COD/(mg/l)	25 000 - 50 000	200 000	≤ 750	≤ 500
BOD/(mg/l)	15 000 - 30 000	120 000	≤ 300	≤ 250
Suspended matter/(mg/l)	2500 - 5000	100 000	-	25
pH	3.0 - 4.5	3.2	5.5 - 9.0	
Temperature	98 °C	30 °C		
Alcohol/(% v/v)	0.92 - 0.1	5		

Source: Auneau(18).

The other Mauritian distilleries use different methods. For, although they face the common problem of disposing of 8 Ml of vinasse

each year, they attempt to resolve this independently, without contacting the other two or even the MSIRI (with one exception).

Solitude distillery used to dilute its vinasse with irrigation water and put the diluted vinasse through its overhead irrigation system. The acid solution corroded the pumps (but not the tubes or water cannon(18) ), especially when the water supply was cut off by the water authority, resulting in undiluted vinasse passing through the irrigation pumps(23). So the manager and his chemist had been trying to find ways of neutralizing it. Lime was tried, but found to be too expensive(13). A French student working at MSIRI for a short time, M. Leveque, did some work on growing Candida utilis on vinasse, including pilot scale experiments at the Solitude distillery(12). These were carried out in a 200 l fermenter (see figure 5.9) with an agitator designed so that its turning would draw in air, through its hollow shaft, in order to aerate the mixture. The yeast was separated using a Westfalia SAOH 205 centrifuge (which recovered 70% of the solids in the suspension, so it was not the most efficient that could be used for yeast recovery). The pH increased from 4.0 to 7.0 in 18 hours at around 25 °C, using a substrate of vinasse with the addition of 0.1% ammonium sulphate. The yields obtained were 1.3 and 6.2 kg dry yeast for an ethanol production of 100 l. The latter yield is a good one for the process.

When M. Leveque left Mauritius this work stopped, and, as the O.K. distillery did not express any further interest in this, the fermenter was in 1977 collecting dust at MSIRI. Although Auneau(18) claims that:

Les quantités d'air à insufler et l'agitation qui doit être pratiquée n'ont pas permis d'extrapoler dans ces conditions

Figure 5.10  
Experimental  
fermenter  
used for the  
growth of  
Candida  
utilis on  
vinasse in  
Mauritius.

Source:  
MSIRI Annual  
Report  
1974(4)

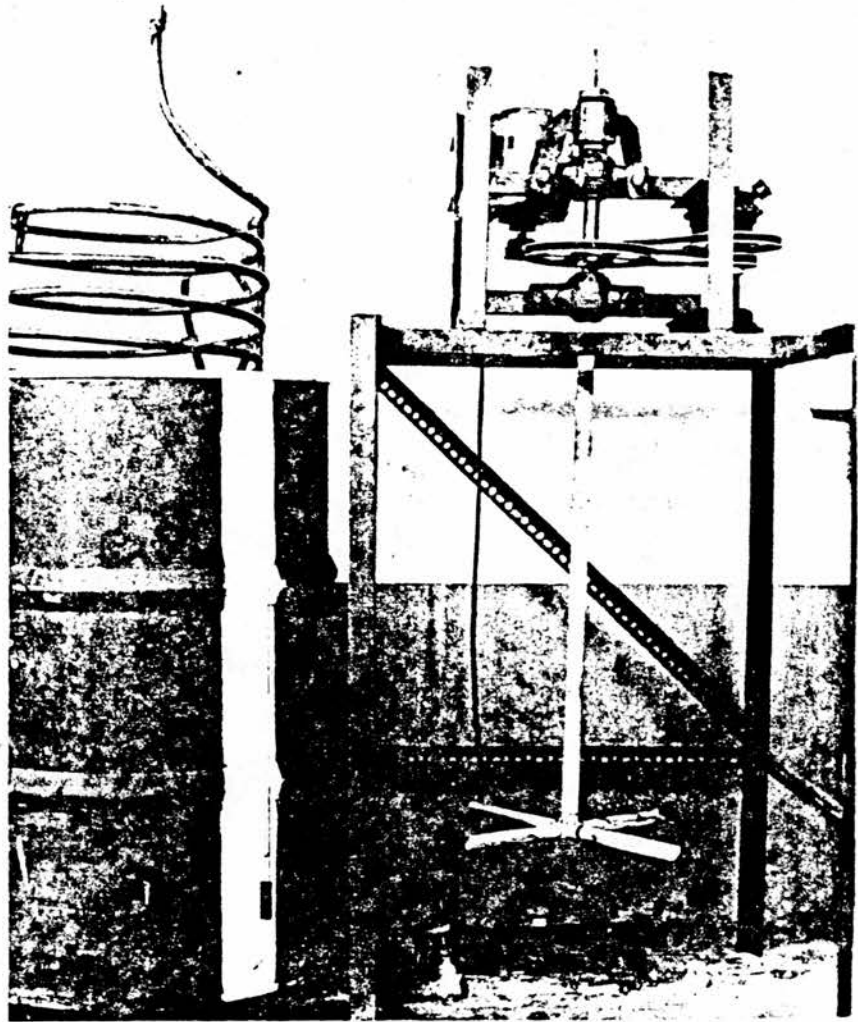


Plate IX Pilot fermenter components. *Left*, fermenter tank and cooling coil. *Right*, air-inducing agitator.

ces essais à l'échelle industrielle à Maurice.\*

However, it appears unlikely that such a conscious, planned decision was made as I never heard this justification mentioned by anyone I interviewed at the Solitude distillery or MSIRI.

The third Mauritian distillery, at Médine, sprays the vinasse on to heaps of bagasse piled up to 1-1.5 m. This is continued for two(24) or three to four(18) months, by which time the material has formed a fine black compost with little remaining fibrous material.

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\* The quantities of air which have to be blown and the agitation which must be carried out do not permit the extrapolation of these experiments to the industrial scale in Mauritius.



This compost, at 70% moisture, is spread on the estate's plantations at a dose of 24-36 t/ha(18). The compost is considered to be a better fertilizer than the filter mud or farm manure. At Médine estate, organic matter is found to be useful as it is in the driest part of the island, yet the cane is burned before cutting, which allows higher evaporation and decreases the soil organic matter content(24).

This compost compares favourably with bagasse compost made with bacterial starter cultures but without the addition of nutrients (such as vinasse). One such starter culture was under test in Mauritius in 1976. The culture was marketed under the trade name "Cofuna"\*\*. This, when mixed with 45% bagasse and 45% filter mud produced a compost in four months, similar in appearance but with low levels of inorganic nutrients. It did not do well in trials of sugarcane and potato growth on good soils(25).

At Panipat Cooperative Distilleries, IRs200 000 were being invested in an effluent treatment plant, using a process developed at the National Sugar Institute, Kanpur. This is a semi-anaerobic process in which ammonifying bacteria are cultured in lagoons on diluted (1+2) vinasse. The bacteria produce ammonia from the nitrogenous compounds in the vinasse, in this way neutralizing the effluent. They simultaneously reduce the BOD from 15 000 ppm, initially, to 3000 ppm, after 96 hours. The treated vinasse contains all the nitrogen (as ammonia), phosphorus and potassium that entered the lagoon, so it is a good fertiliser. After further dilution, to reduce the BOD to 500 ppm, it is used for irrigating the cane fields(18,26).

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\*\* Compagnie des Fumures Naturelles.

Other Indian distilleries rely on simple lagooning, with no special bacterial cultures, or any aeration or mixing to accelerate the biological decomposition of the organic matter in the vinasse. These require retention times of 35 to 60 days to reduce the BOD to 3000 ppm(6).

The Egyptian distilleries do not treat their vinasse. In 1979 they were studying the possibility of producing fodder yeast on vinasse(5).

This completes the comparison of the technologies used in these five distilleries. Following consideration of the markets available for alcohol from such distilleries, the appropriateness of these technologies to the conditions under which the distilleries operated will be discussed. This involves consideration of the history of how they arrived at the present technologies, and the present forces acting for, and against, further technical change.

### 3. Markets for ethanol.

The simplest market for any fermentation ethanol producer is the sale of potable spirits. Ethanol produced from petrochemicals cannot be used for this (except for some Mafia produced Italian wine), the quality is not too critical as long as the alcohol is distilled to 94% or more\*, and the price people will pay for spirits is always enough to ensure a profit even with a somewhat inefficient process. For example, in 1976, the Mauritian distillers sold their alcohol at

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\*In Moçambique "brandies" made by mixing 95% industrial alcohol with imported flavours are eagerly sought despite their commonly acknowledged awful flavour and a price of more than the equivalent of US\$7.

Rs3/l (on a 100% basis) to the bottlers, the government took Rs23 as tax, and the bottlers diluted the alcohol to 40%, added flavours and sold the cane spirit at around Rs10/70 cl bottle (for the cheapest brands). Naturally, no Mauritian distiller will reveal his production costs, but estimates have been made of Rs1-1.25/l(27), Rs1.77/l(8) and Rs2.25(24). Rs3/l is a reasonable return on any of them, as the capital equipment was written off years ago.

It is difficult to produce a good matured rum which will sell internationally. This requires good control of the fermentation conditions and the use of special mixtures of yeasts, to produce the impurities or "cogeners" which give rum its distinctive flavour, and of the distillation, to avoid removing these cogeners from the rum. Also needed is the working capital for keeping the rum in casks for five to seven years. These casks have to be bought fresh each time; Gilbeys' distillery in Mauritius uses old sherry casks. A 30 year old 18 000 l wooden vat (as used at Médine for producing their "Vieux Rhum") is no good at all.

Once produced to the required quality, there is no guarantee that the rum will sell. As consumers and distributors tend to buy well known brands, it is difficult for new brands to enter the market. Panipat Cooperative Distilleries manage by selling their long matured rum to a British company and a German one who sell the rum under their own brand names ("Tropicana" in the case of the German company)(26). Are these sales made possible by the well-known brand names or the marketing organisations of the European company? Well, even the multinational Gilbeys organisation has difficulties in getting merchants to stock their unknown Green Island brand, which they produce at their Mauritian plant. They try to market it in Hong

Kong, Bahrain, Australia, the Seychelles, South Africa, Spain, Belgium, Luxembourg, the Netherlands and the UK - yet they have to rely rather on the more expensive end of the Mauritian market and the tourist trade. In 1976 they were only running at one third nominal capacity\*\*, producing 5.5 Ml/a.

Alternatively, pure 96.5% ethanol can be produced for blending in drinks which depend on flavours derived from other sources. On this basis, the OK Distillery in Mauritius has been blending Ricard and other spirits, using ethanol refined in its third column at the Solitude distillery, and, more recently, in its new distillery at Beau Plan. They have also exported some high-grade ethanol for blending in such spirits. Of the distilleries studied, only the OK and Gilbeys distilleries in Mauritius could produce extra fine ethanol to international standards.

More easily produced is industrial alcohol. However, this market is still dominated by ethanol synthesised from ethylene. According to Johnston, the Product Manager for Ethanol for Union Carbide, fermentation ethanol would not become viable before 1985, except as a by-product of high fructose corn syrup(28). Other countries produce a higher proportion of their industrial alcohol by fermentation, such as Japan (44%(9a)),, Brasil, Egypt and India. These countries do not, in general, have large resources of natural gas for ethylene production, or the ethanol market to justify a synthetic ethanol plant, or they produce industrial alcohol as a by-product of other processes (e.g. from sulphite liquor wastes from pulp mills) or policies (e.g.

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\*\* Although some parts of the plant had not been expanded to the full nominal capacity. The bottle washing machine, bought secondhand, was running at full capacity and was not to be replaced until the market demand required it.

from wine surpluses in the EEC). In brief, fermentation industrial ethanol can be sold at present to specific regional markets, but not internationally.

Finally, fermentation ethanol is being used as an automotive fuel, both alone and blended with gasoline. This has already been discussed in the literature survey. It is mainly countries with surplus agricultural production (or production potential) which have invested in fuel alcohol distilleries. Where a tradeable raw material such as molasses is to be used, and where there is no problem in transporting the molasses to a port, fuel alcohol production is generally uneconomic to the entrepreneur, and will depend on government subsidies.

#### **4. The rationality of conservatism in the industry.**

Few studies have been carried out, in any detail, of small, traditional, alcohol distilleries†. They have either been accepted without comment, or dismissed without study. Yet, worldwide, such small-scale distilleries are very common. Why should this be so?

It is best understood by considering the historical development of particular distilleries. In Mauritius, the Médine, St. Antoine and Solitude distilleries are the result of a concentration of the cane spirit industry on the island, after the end of alcohol exports to the UK, in the early 1950s. Tariff barriers had been erected to protect the UK spirit producers, as soon as they managed to regain their

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† One exception is a study made some years ago of the distilleries owned by SINAGRA (Sociedade de Indústrias Agrícolas Açorianas), in the Azores, by Cross de Chavannes of Booker Agriculture Ltd. This has not been considered here, as the distilleries are based on beet molasses rather than cane molasses.

prewar production capacity. As there was no possibility of competing with the inexpensive gasoline of the period, the only market was in the production of local spirits. Many distilleries were closed, sometimes with equipment being transferred to those which were still operating. In return, the former distillers received shares in a distillers association, which profited from the operations of the remaining distilleries. The spirit market was divided between the three working distilleries, which were run as small adjuncts to their neighbouring sugar factories, which themselves were part of the larger groupings of WEAL, Harel Mallac and Denoncla.

In these circumstances, it is not surprising that the owners of the distilleries or the operating companies took little interest in "modernisation" of the distilleries. For this small, unimportant, sideline gave good profits without any further investment, as people are willing to pay high prices for cane spirit. The owners' conservatism was perfectly rational, resulting in no interest in new technologies. Indeed, this was the technology appropriate to the purpose of producing limited quantities of cane spirit, at prices affordable by a large proportion of the Mauritian people.

It was not, however, so appropriate to producing high quality rum or cane spirits for export, or fuel alcohol for blending with gasoline, or for limiting the pollution caused by the factories. Such criteria were not those used by the owners. In their own terms, there was no rationale in investing in the distilleries\*. Bald statements that such conservatism is perfectly rational, or that it

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\* With the exception of a few small, extremely profitable, investments that had been suggested by their managers, such as perfume compounding.

is irrational, imply that a set of idealized criteria have been applied to a situation, without considering the material circumstances of the factory within a society and, for privately owned factories, its possible markets. So the fixed, and limited, criteria of the owners lead to the conclusion that no new technologies need be introduced into the distilleries, whereas the different criteria of the "Engineering men" of Wells(9b) led them to introduce technology into their factories which was more capital-intensive than was economically necessary. Both decisions are rational under their own criteria, what can be questioned is the continuing relevance of these criteria to the reality of the industry, and its interactions with its physical, economic and social environment.

This reality changes with time. One example of this is the changing attitude to pollution in India, Egypt and Mauritius, which has led to recent interest in all three countries (as elsewhere) in ways of treating vinasse. For example, the increase in tourism in Mauritius led to a demand for higher quality cane spirits, which was first met by an outsider, Gilbeys, who set up a new distillery capable of producing better tasting cane spirits at a higher price. The criteria that had been used by the Mauritian distillery owners were no longer relevant. This realisation came as a shock to those in Mauritius who had supported the conservative line of those in the distillers ring. Although their anger was aimed at Gilbeys, rather than the local distillers, it was from then on less socially acceptable within the Franco-Mauritian community to take the technical conditions of the distilleries for granted. Not only the economic but also the social conditions had changed, leading to a change in the criteria used by some members of this group which had previously



espoused a rational conservatism. Consequently, when plans were made to close the Solitude sugar factory, a decision was taken to build a new distillery at Beau Plan, making use of newer technologies. Such interactions between a technology and its environment, and the dynamic nature of the processes involved in the selection, design and introduction of technologies, are discussed in the conclusions.

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## CHAPTER SIX

### Pulp and paper production from bagasse - alternative technologies.

In this chapter is outlined the history of proposals for pulp and paper production from bagasse in Mauritius, a comparison of two technologies for this, one medium-scale, one small-scale which shows that well run Indian mini mills can be more profitable than a proposed chemimechanical pulp mill for Jamaica. Furthermore, the Indian data are recalculated at Mauritian prices to see if a mini-mill could be viable in a higher-wage economy. The purpose of this chapter is to study the alternatives in a selected use of sugarcane by-products, as very often unjustified arguments of "overriding economies of scale" are used to dismiss alternative solutions out of hand.

#### **1. Pulp and paper production in Mauritius**

The production of bagasse pulp in Mauritius has long been discussed but never undertaken on a commercial scale. The MSIRI report, "By-products of the sugar industry of Mauritius"(1) recounts the history of proposals and occasional experiments, such as the production of one page of the Revue Agricole of 1889, and specimen sheets of cardboard shown at the 1887 Colonial and Indian Exhibition in London.

From 1951 to 1955 there was some interest, on the part of Forges Tardieu Ltd. and some sugar factories, in the production of paper from bagasse. They retained the Cellulose Development Corporation Ltd. as consultants. In October 1952, the Cellulose Development Corporation Ltd. sent Dr. Raimondo to Mauritius. He recommended an extremely economical plant, at Mon Loisir, producing 500 t/a low grade wrapping paper by a lime cook of bagasse. This 5 t/d mill would

have operated only during the crushing season, using sugar factory steam and electricity. The estimated 1961 cost was Rs1.2 M, including only Rs50 000 working capital(2). The project was abandoned when the government turned down a request for a loan of half the capital.

In 1952, Prof. Hisey, of the Sandy Hill Iron and Brass Works, reported to Blyth Brothers and Co. on the use of bagasse for domestic fuel, insulation board and hardboard, and pulp and paper. His report concluded against pulp and paper production, but in favour of insulating board production(3).

The following year yet another study was commissioned, this time by the Colonial Office. The consultants, Messrs. Reed and Marsden of the Pulp and Paper Research Co. Ltd. reported lukewarmly on a 3000 t/a paper and board plant, which they preferred to a pulp mill. They described this Rs5.5 M project as "somewhat speculative". It was turned down by the Mauritian colonial government(4).

By October 1956, further visitors were on the island, this time Col. Magill and three representatives of A. Reed and Co. Ltd. They studied the possibility of erecting a 30-60 kt/a pulp mill using bagasse and/or pine ( Pinus eliotti ) planted extensively on Crown and private forest lands. The main drawbacks were the 0.2-0.5 m<sup>3</sup>/s of water required, effluent problems and uncertainties in the bagasse supply.

Since the MSIRI report was issued in 1961, other consultants have reported on the possibilities of pulp or paper production. One of the more detailed was produced by Sandwell and Co. Ltd., in 1969, on the "Utilisation of bagasse in Mauritius"(5). They estimated a bagasse surplus by 1975 of 123 kt/a (bone dry basis), on an estimated

production of 660 kt sugar, 1570 kt wet bagasse or 770 kt dry bagasse. If the pith (35%) were burned in the furnaces, releasing more bagasse fibre, the total surplus fibre would be equivalent to 190 kt/a. They suggested a Rs3.1 M, 45 t/d particleboard plant, and a Rs12.3 M, 100 t/d pulp mill (for export). At 3.62 t dry bagasse/t pulp and 1.61 t dry bagasse/t board this would require 140 kt/a dry bagasse which would be within the surplus production estimate, provided that the pith is burned in the sugar factory boilers. On the basis of water availability they proposed five possible locations for the pulp mill, as shown in figure 6.1.

Figure 6.1 Water availability for a pulp mill in Mauritius

Location	Water <sub>3</sub> supply m <sup>3</sup> /d	Max. mill size air dry t/d
Beau Champ	110 000	700
Savannah	18 000	120
Union St. Aubin	18 000	120
St. Felix	18 000	120
F.U.E.L.	25 000	160
Médine	25 000	160

In 1971 the Indian Government Techno-Economic Mission to Mauritius suggested setting up both a 100 t/d newsprint mill (for export) and a 2 t/d grey cardboard mill (for local consumption)(6).

According to their "project profile" the newsprint mill would only have cost Rs117 M, no chemical input would be required (p.140), the mill would consume annually  $8 \times 10^6 \text{ m}^3$  water, 28 kt furnace oil, 38 GWh electricity (one quarter of the electricity generated by the CEB in 1972), 57 250 t bagasse (bone dry basis) and 1570 t of imported bamboo pulp. This was considered by the Indian team to be the minimum economic size, in 1971, for a newsprint mill. Their

market analysis is contained in one sentence: "The market for export should be studied before taking a decision to implement the project." (p.137). They stated that the plant should use the Simon-Cusi process, but their process description does not explain why the digested bagasse is separated into fully and partially digested fibres, or why the longer fibres are mechanically refined before being blended with the shorter fibres.

Their "profile" of grey cardboard manufacture is unusual in as much as the flow sheet includes a straw cutter. This, together with the use of lime alone to digest the bagasse (normally NaOH is used to avoid long digestion times leading to very weak fibres), shows the attention to detail and professional competence typical of this mission.

More recently Sybetra, a Belgian paper company, together with Simon Engineering considered erecting a Rs600 M, 350 t/d bagasse pulp mill in Mauritius. They got as far as signing contracts to replace bagasse by fuel oil, but, at the time of the final feasibility study, they did not have the money to invest in the plant. During a subsequent European Development Bank visit to Mauritius this plan was put forward by the private sector there. It was left for the European Development Bank to contact the Belgian company, but nothing more was heard of this(7).

The Birla group in India had had discussions about setting up a small semi-bleached pulp mill to produce cardboard and wrapping paper(7). Nothing came of this, perhaps because of the establishment of Packaging Industries Ltd. (see below).

An Indian businessman, <sup>who</sup> <sub>^</sub> has visited Mauritius several times,



intended to set up a newsprint mill there to supply the Indian market. In 1978, the project was to produce 145 kt/a newsprint in a Cusi process mill which was estimated to cost Rs  $1.1 \times 10^9$ . This project was criticised in PROSI Bulletin for the lack of a guaranteed export market, a shortage of surplus bagasse\*, a water shortage, even at Grand Port, where the Ferney dam could not supply  $45 \text{ m}^3/\text{min}$ , and pollution hazards(8). Many Mauritian businessmen thought that this Indian entrepreneur was after their money to invest in the project, and, therefore, kept out of it. In fact, he returned later several times, most recently, in 1981, with a plan to produce 90 kt/a newsprint and 40 kt/a writing paper using a Swedish improved depithing technology. The plant is to be on barges sunk off Mahebourg, using water from the new R. Champagne project and about 670 kt/a of wet bagasse bought on a coal plus pith fuel replacement basis. Negotiations were underway, in 1981, with sugar estates on how this should be calculated. The estimated investment was then Rs  $1.2 \times 10^9$ (9).

Meanwhile a pulp and paper mill has been built in Mauritius, although not as yet using bagasse. This is the factory of Packaging Industries Ltd., set up by M. Lagesse, which produces packaging paper from paper waste. The waste paper is pulped in a hydropulper, then passed through a separator to remove plastics and other contaminants, to a simple paper machine which uses formers and vats rather than the continuous belt fourdrinier system. The paper is then dried and sprayed with starch to improve impact properties. M. Lagesse had started in a small way, with three men and one or two machines, and built up from that. In 1976, he had a factory producing 1000 t/a

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\* It is not clear why Beaubois did not consider fuel replacement for bagasse, instead of just the surplus bagasse availability.



employing 20 people and using mostly (90%) secondhand machinery. Production of fluting and liner paper was planned to start in January 1978. He was also considering the use of bagasse later, after he was using all the local waste paper (600 t/a collectable out of 1000-1200 t/a waste) and imports from Réunion.

Despite all the studies, reports and consultancies only one pulp/paper mill has been set up in Mauritius. Why is this? What factors led to M. Lagesse's success where British and Belgian paper companies feared to tread? Among the reasons are the following:

- i. Packaging Industries Ltd. is a marketing-oriented company. M. Lagesse studied several hundred possible industries before choosing to set up a plant producing packaging paper. He studied the marketing opportunities before choosing his industry, unlike all the other studies.
- ii. Having chosen his market he went and studied existing plants producing such products, at the scale of the Mauritian market requirements rather than plants of a reputed "minimum economic scale". He said he does not think anything of economies of scale - the market comes first.
- iii. He used 90% secondhand equipment, thereby reducing capital costs.
- iv. He used simpler, slower, paper machines which were adequate for the Mauritian market; formers rather than fourdrinier machines.
- v. Before starting operations he had thoroughly studied the business elsewhere and made a point of talking not only to the managers but also to the workers, who knew exactly what could go

wrong with any machine. This enabled him to make a good selection of secondhand equipment and to maintain it with few unforeseen problems.

- vi. He built up production gradually, instead of building a large plant at once and then trying to find enough waste paper to run it to full capacity, and large local markets all at once. In this way he could meet any problem as it occurred.

The dynamics of the establishment of this business show that it is an appropriate technology not just in its suitability for the local market conditions, not just in the way the reduced capital costs took advantage of Mauritian factor costs, but in its social trait-taking - a dynamic fit to the small entrepreneur in Mauritius. The other proposals, if implemented, would have been trait-making rather than trait-taking. Mauritians would have to learn how to market pulp or paper overseas, to tolerate a lot of pollution in one place, to change water and electricity supply plans to meet "les exigences enormes de cette industrie"(8), to convert some sugar factories to burn oil or coal, to learn to operate complicated, unfamiliar equipment with little hope of applying these skills elsewhere.

But most important of all the traits that would be necessary for the success of a large pulp mill is the institutional cooperation required. The plants would be so large that the venture would have to be undertaken by a foreign company, or by the government and all the sugar industry. Only when the investment has been directly beneficial to the sugar industry has this degree of cooperation been achieved in Mauritius - in the cases of the fertilizer factory and the bulk sugar terminal. With such institutional difficulties it seems that foreign

investors could more easily establish a large pulp mill in Mauritius. Hence the approach of the previously mentioned Indian businessman—Indian market, Indian investment, Swedish technology—by this means he can bypass many of these difficulties. Even so, this will take time. If bagasse pulping in Mauritius had been approached in the same way M. Lagesse approached packaging paper production, there might already have been bagasse pulp mills in Mauritius, producing paper for the local market.

This possibility will be discussed later, when the possibilities of establishing mini-mills of Indian design in Mauritius is considered.

## **2. Pulp and paper production from bagasse in Jamaica and India.**

"Sugar by-product utilization in Jamaica" is the title of an Organization of American States report written in 1977, in which was attempted an assessment of the techno-economic potential for the utilization of sugar by-products to produce pulp and paper, animal feeds and anhydrous alcohol(10).

The terms of reference for the part of their study concerned with pulp and paper production were to undertake a demand analysis of anticipated future markets for paper and paperboard in Jamaica and the Caribbean Common Market (CARICOM); a supply analysis of island and local bagasse availability; to determine the best alternative project; and to undertake financial and economic benefit analyses of this project.

The study began by reviewing 13 previous studies on pulp and paper production in Jamaica or the Greater Caribbean Region. These

considered the following projects for Jamaica:

- i. A 160 t/d or 50 t/d integrated pulp/paper mill to produce corrugating medium from bagasse(11).
- ii. A 200 t/d corrugating medium from bagasse mill, a 10 t/d tissue mill from waste paper and imported bleached pulp, and a 50 t/d mill to produce liner, wrapping paper and corrugating medium from used containers, the waste from a corrugated box plant and imported waste paper(12).
- iii. A 32 kt/a mill for the major paper grades and paperboard for industrial use and a 9 kt/a creped tissue mill, using 17 kt/a bagasse (pulp?)(13) A 100 kt/a newsprint mill based on Pinus caribaea or alternatively a 30 - 40 kt/a bagasse based newsprint mill if no corrugating medium mill were built(14).
- iv. A thermo-mechanical pulp mill based on P. caribaea to produce newsprint and printing and writing grades - at first 16 kt/a printings and writings or 18.7 kt/a newsprint, later to be expanded to 35 kt/a, and a 10 kt/a linerboard and corrugating medium plant based on imported kraft pulp and waste paper(15).

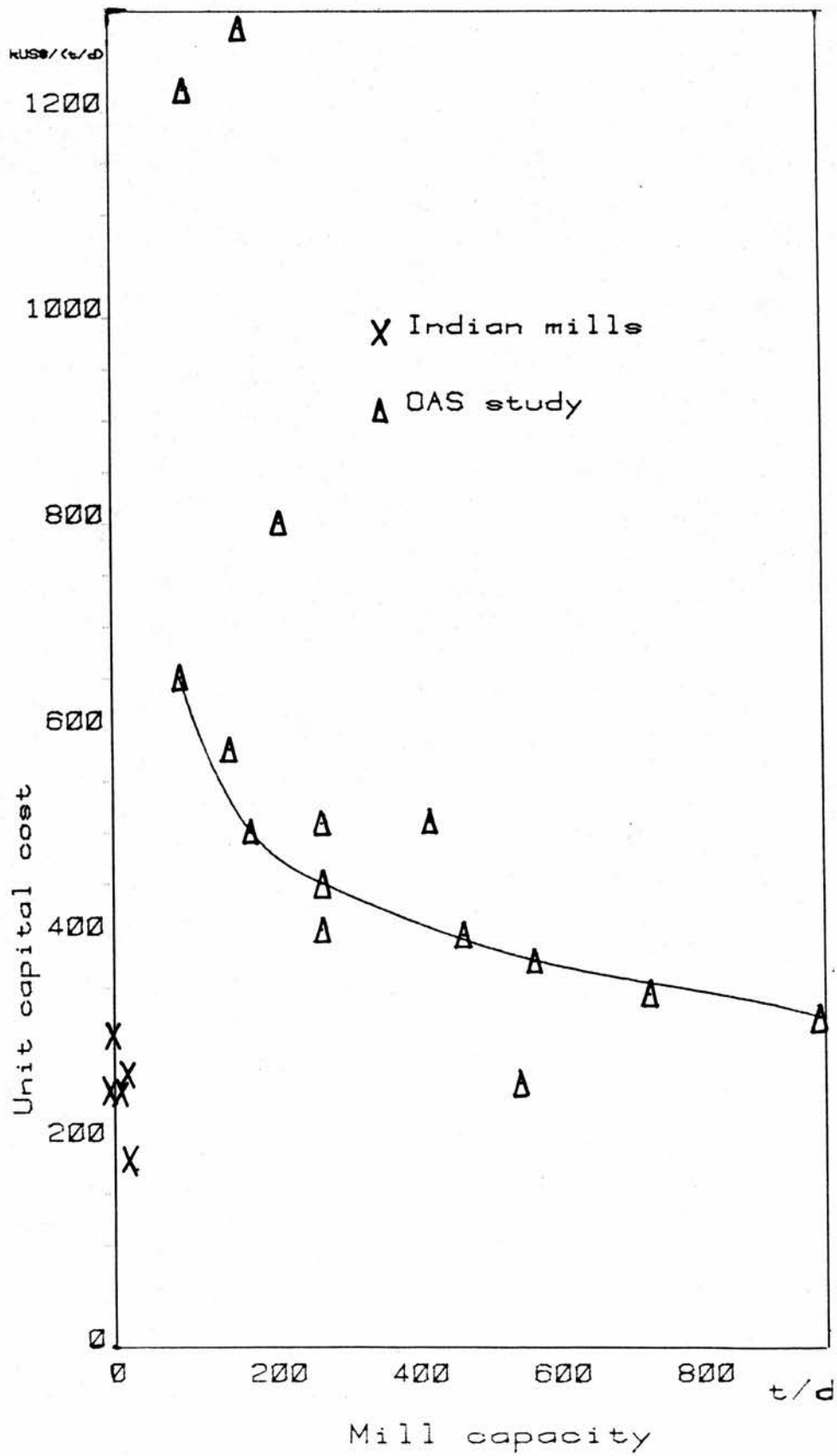
These projects were of two types, large mills, which would have to export a large proportion of their production, and smaller mills, which were designed to produce only a small surplus over Jamaica's consumption of 60 kt/a in 1974 (c.10% newsprint, c.15% printing and writing paper, most of the remainder packaging paper, especially banana boxes)(10). To choose between these alternatives an export market survey is needed. Such a survey was specified in the terms of reference of the OAS study but was not carried out. Instead the

authors of this report merely stated that any Jamaican exports would not be competitive with the production from the Olancho project in Honduras and the other four projects proposed in the FAO regional study(15), as these mills would benefit from economies of scale.

Such an assertion ignores the fact that the FAO study proposed <sup>that</sup> a thermo-mechanical pulp mill be erected in Jamaica concurrently with these four projects, and other mills be built later, phasing the plant erection to meet an increasing regional demand for paper. This demand was 575.7 kt/a in 1972-4 and was estimated at 844 kt/a by 1981 and 1.4 Mt/a by 1991(10,p.91). The FAO proposal to start 400 kt/a of new pulp mills between 1982 and 1985 is half of the 1981 estimated consumption, so all these plants should be able to sell their production provided that they could maintain prices below those of imports from developed countries (USA, Canada, Scandinavia), rather than needing to compete with each other. This does not mean that Jamaica would be able to export pulp or paper, merely that the argument used by Proenza and Collins in the OAS study is false.

So, they decided that any Jamaican mill would have to produce only for the local market. Logically, this would require the assessment of the local market and small-scale production systems, and then designing the most economical plant to fit the local conditions. Unfortunately, they had already restricted their choice of technology by a discussion of economies of scale on pages 80-6 of their report. This they based on a costing of several recent integrated pulp/paper projects, which they presented in their figure III.1 (p.81) which is presented in figure 6.2 together with capital costs for small-scale Indian paper mills taken from Western's report, 'Small-Scale Paper-making'(16).

Figure 6.2 Variation of unit capital costs of integrated pulp/paper mills against plant size.



From their data Proenza and Collins concluded:

From this discussion it will be apparent that a full chemical bleached pulp mill, using any fibrous raw material, of 200 tpd production capacity must be considered the very minimum size in view of today's building costs. To build a pulp mill of this small (sic) size in any developing country can probably be justified only on the basis of national interests including the savings in foreign exchange. However, in many situations, such as in Jamaica, this mill would be too large for certain products that are needed to supply the market. A mill of small size would require the protection of a high import duty or a closed border to make the project financially viable in providing a modest rate of return on investment or equity. The local production in small mills of paper from full chemical pulp produced locally will, therefore, usually require much higher sales prices than for paper at the world market prices for such products.

The reader may be wondering how 200 t/d can be the minimum size when the unit capital costs of Indian mills producing from 1 t/d to 30 t/d are less than the 200 t/d mills assessed by Proenza et al.\* They do mention this, but dismiss such mills with the following argument:

The question may arise as to how it has been possible to build some small low cost pulp/paper mills in some developing countries. It is the case that in India and neighbouring countries there has been a drive to install cheap units in the range of 10 to 50 tpd productive capacities. These mills are often built with secondhand or locally built equipment of simple design. The product qualities and the processes would not meet world market requirements or those of a developed country even in the few cases where the fibrous raw material would be adequate. Many of these mills pulp agricultural residues and other nonwood plant fibers at atmospheric pressure and/or bleach by very antiquated methods. There is usually no recovery of spent liquor in these mills, a factor which makes tolerable the very high per ton costs of chemical inputs. The resultant stream pollution, however, would not be tolerated in most countries; and certainly not in Jamaica.

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\* The capital cost figures are not strictly comparable since the figures quoted in the OAS study include pollution treatment, chemical recovery and power generation equipment, whereas the Indian mills usually buy electricity from the grid, buy in chemicals and only carry out a primary treatment (if any) of the effluent.



Such a hand-waving dismissal is less than adequate. Having decided that the Jamaican market would not support a large-scale plant, they should have investigated the economics of such mini-mills rather than depending, like politicians, on hearsay and secondhand impressions. By so constraining their freedom of choice, they had to suggest a semi-mechanical pulp mill to be blended with imported bleached softwood sulphate pulp to produce newsprint and printing and writing paper. Semi-mechanical (thermomechanical or chemimechanical) pulping depends on a pre-softening of the lignin in the fibres by heat or a short chemical treatment, before the cellulose is separated by mechanical refining. The suggested chemimechanical process is shown in figure 6.3

Was this choice of chemimechanical pulping technology the appropriate one for Jamaica? It is interesting to compare the costs and benefits of producing 25 kt/a of paper in the proposed mill, with the same production from typical Indian mills studied by Western(16), namely 5x15 t/d mills, <sup>and</sup> 3x25 t/d mills, using straw pulp together with small quantities of waste paper, rags or imported pulp. The capital costs of these mills are about half of the cost of the proposed mill for the same production, as shown in figure 6.4.

We see from figure 6.4 that the total investment for a series of mini pulp/paper mills is far less than that of the larger chemimechanical mill. It should also be noted that a 30 t/d plant, discussed in Western, required only a total capital investment equivalent to US\$13.7 M for 25 kt/a of paper. Furthermore, it is evident that these mills need not all be built at the same time, but can be built when the demand exists for each one. The foreign

Figure 6.3 Chemimechanical pulping of bagasse.

Source: This is figure V.1 on p.119 of OAS study.

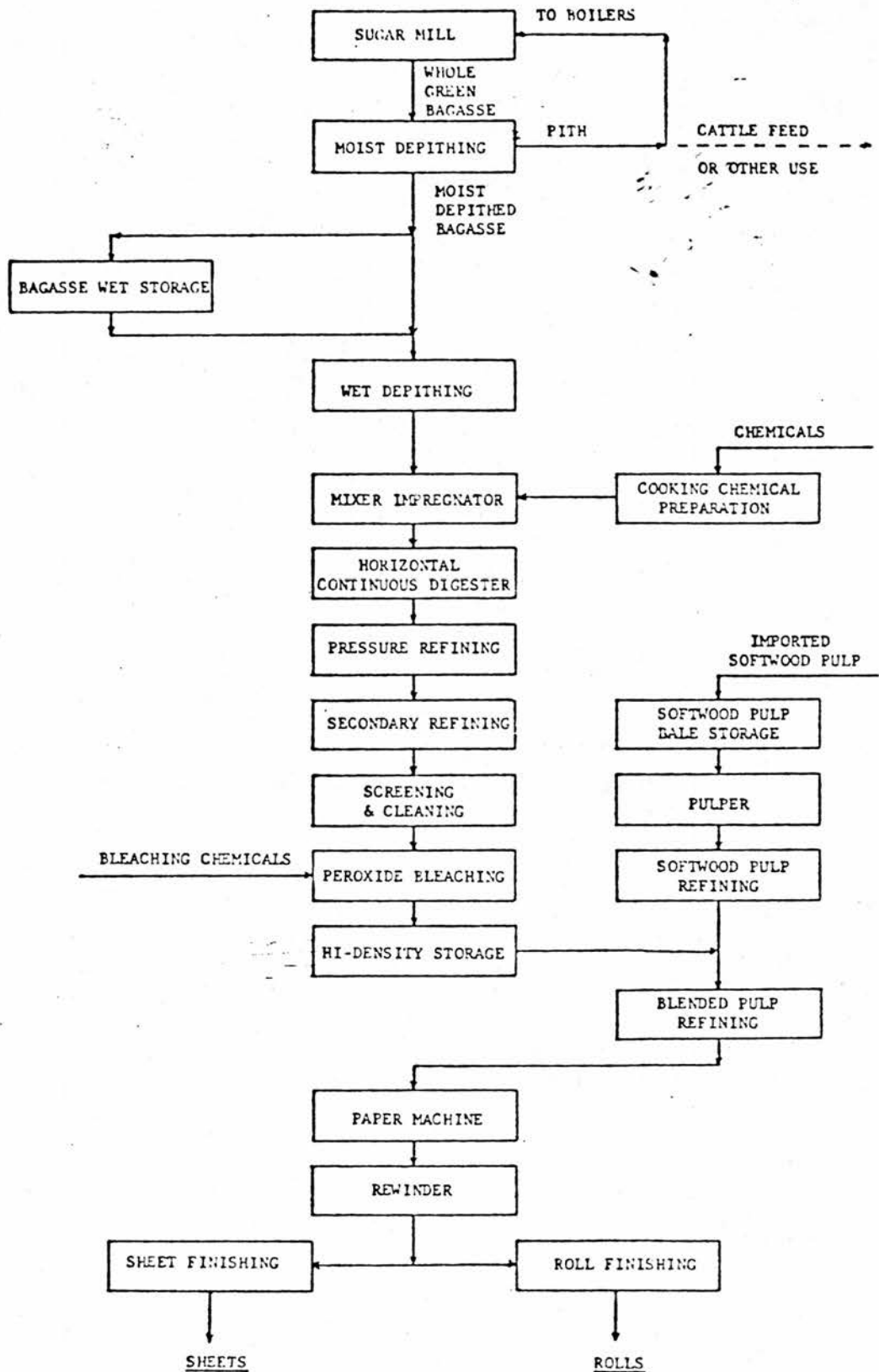


Figure 6.4 Capital requirements for the production of 25 kt/a paper(10,16,pp.121-3,127-9).

kUS\$	OAS study ~75 t/d	Indian plants	
		5x15 t/d	3x25 t/d
Land + site development	700	300	394
Buildings + structures	2940	1475	2205
Total land + civil works	3640	1775	2599
Machinery + equipment	20640	11324	10659
Erection	3480		750
Eng. + tech. services	2248	375	347
Personnel training abroad	212	0	0
Prestart-up expenses	1820	625	713
Spare parts + consumables	2064	213	225
Sundries	0	813	938
Contingencies	3264	782	788
Total of other items	13088	2806	3759
Total fixed capital	37368	15905	17025
Working capital		2438	2813
Total project cost		18344	19838

currency requirements for the smaller plants are also usually less. The 15 t/d mill uses all Indian made equipment except for a machine glazing cylinder, whereas the 25 t/d plant saved foreign currency by importing second hand machinery (two 15 t/d paper machines). Moreover local suppliers and contractors charge less for erection, engineering and technical services, and no foreign training is necessary.

It is well known that small-scale plants often have lower capital costs but higher running costs. These costs are compared in figure 6.5, where the production costs per tonne of paper produced have been calculated for the OAS proposal, the 15 t/d and 25 t/d mills outlined in Western, and for a costing for bagasse based mini-mills

of 15 t/d as proposed by Rao(17).

Figure 6.5 Unit cost of production for small and medium scale mills.

Item	Unit costs / US\$/t			
	OAS 75 t/d	Western 15 t/d	25 t/d	Rao 15 t/d
Fibres	111	103	192	76
Chemicals	49	91	191	80
Energy	120	82	88	73
Packaging	8	12	15	6
Labour	89	58	51	36
Maintenance	20	29	28	18
Insurance	2	-	-	-
Office & sales	3	*	*	17
Contingencies	-	-	-	6
Total	402	375	565	312
Capital charges	298	102	110	70
Total	700	477	675	382

Notes:

\* These are included in the office labour costs.

1. The OAS figures have been corrected for a calculation error (6 111 t of pulp at J\$450.80/t cost J\$2 754 839, not J\$275 484 as given).

2. The calculations are approximate, in that the capital costs represent the annual payments over 15 years necessary to pay back the capital at an assumed rate of interest of 11% annually, assuming production at 100% of capacity. In fact, the 25 t/d Indian plant was only operating at 70% of full capacity, which figure was used in reducing the fixed production costs to a per tonne basis. The calculations do allow for the greater construction time of the largest plant (4 years) as opposed to not more than one year for each small plant.

The smaller plants cost less to run, because of cheaper, local, raw material sources, and because these particular examples produced some semi-bleached pulp, therefore, saving on the cost of bleaching compared to the 25 t/d printing and writing papers mill. The chemical

costs are higher in the three smaller mills since there is no chemical recovery. The labour costs in India are lower despite the greater number of workers employed. (For the production of 25 kt/a the chemimechanical mill would employ 329 people, 15 t/d straw based mills would employ 2840 people and the 25 t/d straw based mills would employ 1720 people). The reduced wage bill is partly due to the lower wage rates in India, and partly due to lower requirements for skilled workers in these simpler mills. Furthermore, the mill proposed in the OAS study requires foreign 'experts' for the first three years, costing a total of US\$1.8 M.

So we see that the cost of production of small-scale mills need not be higher than the costs of medium size mills. Therefore, they should not be dismissed out of hand, as in the OAS report. Of course, small soda process mills based on Indian design will be less economic in higher wage economies. Each case has to be considered on its merits, remembering that the Indian mills are based on the technology of the 1930s, which is suited to Indian conditions. In other places, design changes can be made to meet local requirements, with a better chance of designing a mill appropriate to the local economic conditions than by scaling down a large-scale plant design.

In their local environments the Indian mini-mills are far more profitable as figure 6.6 shows. This gives the results of a calculation of the net present value (NPV) of the production and sale of 25 kt/a paper over 15 years by the different mills, discounted at 11%/a, and the internal rates of return (IRR) of each mill.

Such highly profitable Indian operations reflect high paper prices, in a sellers market where there is a lack of investment in

Figure 6.6 Profitability of small and medium scale mills.

	OAS 75 t/d	Western 5x15 t/d	3x25 t/d	Rao 5x15 t/d
NPV/MUS\$	-16.5	25.1	7.1	11.1
IRR	3%	35%	18%	27%

paper production, accompanying import restrictions (except for newsprint)(16,p.52). The selling prices of paper at these four mills is compared in figure 6.7, where the price of imported paper in Jamaica before and after import duty is compared with those of the paper sold by these three Indian mills before and after excise duty.

Figure 6.7 Selling prices of paper in Jamaica and India.

Prices/ US\$/t	OAS 75 t/d News.	P & W	Western 15 t/d Pack.	25 t/d P & W	Rao 15 t/d Mixed
Basic ex-mill/c.i.f.	498	647	600	750	460
Rate of duty	20%	20%	37.5%	25%	?
Including duty	598	776	825	938	?
Rate of rebate	0%	0%	60%	50%	?
Gross sales realisation	598	776	735	844	460
Selling expenses	?	?	45	56	10
Net sales realisation	?	?	690	788	450

(News.= newsprint, P & W = printing and writing, Pack.= packaging)

The Indian prices appear to be around 25% higher than the corresponding international prices—"appear to be" because they have been converted at the official exchange rate. The Indian government import restrictions reflect a shortage of foreign exchange which otherwise would force a devaluation of the rupee. So, their support of such mills can be justified in terms of the social costs and benefits of the local production of paper in small mills. (Although the reasons for this support are undoubtedly political—employment

generation and support of small businessmen pays off in votes.)

Proenza et al carried out an 'economic cost benefit analysis' of their proposed chemimechanical pulp/paper mill under rather dubious assumptions. They assumed a shadow wage rate as being the actual wage rate multiplied by the employment rate as a measure of the average probability that the workers were employed previously. But the average is irrelevant, it is the marginal change in the new workers productivity which is important. A new unskilled post in a new enterprise will be filled by an unemployed worker, not one who had been employed elsewhere. His shadow wage is a measure of his production while unemployed (in odd jobs, family agriculture and so on) which will be lost when he is working in the mill. Also, they assumed that the special exchange rate of Jamaican \$1.25 to US\$1 represented the true cost of foreign exchange (in the two tier exchange rate system in force at the time), although later devaluations show this to have been an unwise choice.

Their economic analysis, when corrected for the previously mentioned calculation howler, gave the following results.

Net present value/US\$ = -29.5 M

Internal rate of return = -7 %

Obviously a hopeless case under these assumptions.

Similarly correcting for gross distortions in the Indian economy, by assuming a shadow wage for unskilled and semi-skilled workers at 25% of their pay, and a shadow exchange rate at 20% over the official exchange rate (i.e. Rs9.6/US\$), and pricing the paper at the average Mauritian import prices for 1977, the following results are



obtained.

5x15 t/d Net present value/US\$ = +4.2 M

Internal rate of return = +16 %

3x25 t/d Net present value/US\$ = +31.1 M

Internal rate of return = +42 %

From this crude analysis we can see the benefits to such an economy of small scale paper mills. Other advantages of such plants include their lower impact on the environment, creating less pollution in one place, and not placing a great strain on services in short supply such as water, electricity, or raw materials. In the case of bagasse based mills, they can often rely on the surplus bagasse from a large mill, rather than having to buy bagasse on a fuel replacement basis as do the larger mills.

The experience of many large pulp mills in buying bagasse on a fuel replacement basis from sugar factories has not been encouraging. Rao(18) described the fortunes of the larger Indian bagasse pulp mills. M/s Seshayee Paper and Boards Ltd (Tamil Nadu), a 35 kt/a paper mill, had a contract with a nearby sugar mill to supply bagasse on a fuel replacement basis. Of the contracted 15 kt/a bagasse (bone dry basis) only 3.4 kt/a were supplied, on average, between 1963 and 1970, so they stopped using bagasse. M/s Mandya National Paper Mills Ltd. (Karnataka), a 21.6 kt/a mill "had considerable difficulties in obtaining sufficient supplies of bagasse" from a sugar factory, where the paper company had even installed a multi-fuel boiler

to meet its steam requirements. They had to bring in bagasse from distant sugar factories(18), before they could reach a

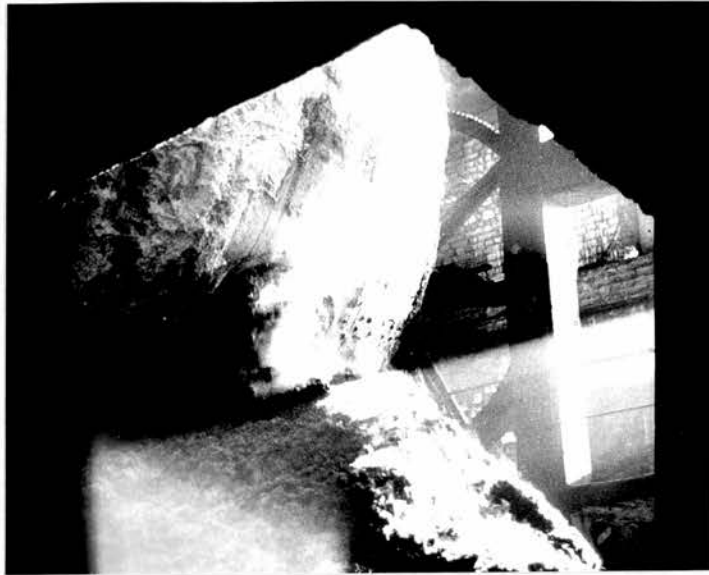
"satisfactory level of production" in 1964(19).

Other large bagasse mills outside India have had to transport bagasse over large distances to meet their requirements. For example, the San Cristobal mill in Mexico has had to transport bagasse for up to 200 miles. Only where the paper and sugar mills are under common ownership have there been no bagasse supply difficulties for the mill, such as the Pingtung mill set up by the Taiwan Sugar Corporation(20). This makes use of bagasse produced by several mills owned by the same company.

Smaller mills have avoided such supply difficulties, either using surplus bagasse from an adjoining mill under common ownership, or being able to buy the small quantities required from whichever neighbouring mills have a surplus at any time. Examples of such mills are Ms. Rajendra Paper Mills Ltd., Hyderabad (4 kt/a); Ms. Venkateshwara Paper Mills Ltd., Tamil Nadu (6 kt/a) (18); the Pravara Cooperative Sugar Factory, Maharashtra (30 t/d), which has been working since 1975 manufacturing kraft paper from 60% bagasse, 20% rice straw and 20% old jute bags, and disposing of the waste liquor as irrigation water in acidic fields (21); and M/s Dhampur Sugar and Board Mills Ltd., U.P., which produces cardboard and corrugating medium. Figure 6.8 shows one of the large bagasse digesters, photographed by the author in 1977.

To return to the Jamaican study, Proenza et al doubt the availability of surplus bagasse, quoting estimates of 60 kt/a (10,p.58), 65 kt/a from Frome sugar mill alone(14), 300 kt/a assuming a 30% surplus(15), a 10% saving of bagasse usage by adjusting the boiler operating conditions, and a 30% saving, of up to 421 kt/a, if new

Figure 6.8  
Bagasse digester at  
Dhampur  
Board Mill,  
1977.



boilers were installed(15), but pointing out that, at that time, many mills continued to burn oil and, <sup>also</sup> at that time, there was only a surplus of around 230 t/a not used for fuel or particleboard production (p.99). As they were only interested in medium or large scale plants, they had to ignore any bagasse surpluses and cost their proposals on fuel oil substitution for bagasse. Two sugar factories would have had to be converted to oil and pith burning, to release the needed quantities of bagasse for the pulp mill and the existing particleboard mill.

Consider a possible alternative, starting with one mini-mill making use of surplus bagasse, using a large proportion of locally made equipment, and producing at low cost until a sufficient market has been established to build more mini-mills using fuel substituted bagasse. This might be a soda process mill to produce printing and writing quality paper with very small or zero additions of longer fibres, or a chemimechanical mill of Indian design to produce wrapping paper. (Many such mills of 10-15 t/d exist in India). Among the advantages of such a progressive introduction of local paper

production are the following:

- i. Each mini-mill can be located next to different sugar mills, thus reducing transport costs for the bagasse.
- ii. The first few mini-mills could use surplus bagasse, allowing time for the sugar factories to install more efficient boilers under the stimulus of higher oil and electricity prices (at least to the extent that Mauritian and Hawaiian factories have already done), thus producing a greater bagasse surplus.
- iii. They are simple to run, involving little or no expatriate support in construction and production.
- iv. The processes are easily understood, providing a learning opportunity for the workers which can be applied in future small or large scale mills, and in other industries.
- v. They are easier to maintain, and provide work for local repair shops.
- vi. Their capital costs are lower per tonne of paper produced (by avoiding investment in independent power supplies, sophisticated waste treatment, expensive buildings and high technology machinery), increasing the financial viability of the mill even at reduced production levels (cf. Universal Board Co. Ltd. and Yeast Producers (Mtius) Ltd. for the effects of producing under capacity).
- vii. The total capital costs are lower, so putting the investment within the reach of the entrepreneur, cooperatives or the single sugar factory. Larger mills in developing countries usually

require massive government and international investment.

- viii. Mini-mills employ more unskilled labour, so reducing unemployment, at a lower capital cost per job created.
- ix. The commissioning time is reduced from four years to two years, for each mill, allowing a much closer matching of production capacity to market demand.
- x. The slower paper machines used in mini-mills allow the use of lower strength pulp, and so a higher proportion of bagasse in the furnish (provided they have a sufficiently long length supported by wire to allow adequate drainage).

Against this must be set the disadvantages of:

- i. Higher chemical consumption, except in the larger mini-mills of 25-30 t/d which practice chemical recovery.
- ii. Higher energy costs, except where integrated with a sugar factory.
- iii. Variable quality production, if not properly instrumented.
- iv. Higher labour costs in high-wage economies.

I would not claim from the foregoing that a series of small mills would necessarily be an economic proposition for Jamaica, as, even with the above advantages, the higher wages might make the venture financially unprofitable. However, given the advantages of mini-mills and the high levels of unemployment in Jamaica (24% in October 1976(10,p.13)), a design adapted from that current in Indian mini-mills would be more likely to meet Jamaica's needs than one

based on US technology. To adapt these simple mills along the lines suggested by Western, in his Appendix IV, and to use machines to replace some of the most labour intensive practices, such as manually cutting rags, would be simpler than to try and change a sophisticated mill.

### **3. Prospects for pulp and paper production in Mauritius**

The chequered history of the attempts to start pulp and/or paper production from bagasse in Mauritius has been outlined in a previous chapter. Despite numerous proposals to establish mills of over 100 t/d capacity based on bagasse, the only paper mill actually built has been a small waste paper based mill, started by M. Lagesse.

What is the best path for the future development of pulp or paper production in Mauritius? Is it to build large mills for export, or mini-mills for the local market, or do nothing? In 1977, 13 kt of paper and paper products were imported into Mauritius, worth in all Rs52 M(22). These imports are summarised in figure 6.9, in which they are broken down into the principal grades of paper.

Even though the Mauritian market for paper and paper products is expanding it could not support a large scale pulp/paper mill. The total 1977 consumption was less than one quarter of the Jamaican consumption in 1974(10). If any pulp/paper mills are to be built for the internal market in Mauritius, they will have to be mini-mills, as is the existing mill at Packaging Industries Ltd. From figure 6.9 can be deduced the largest size mills which could be built to supply the internal market. These would be a 25 or 30 t/d packaging paper mill, a 5 t/d printing and writing paper mill (including some production of industrial grades and coated papers, as some of the printing and

Figure 6.9 Imports of paper and paper products into Mauritius, 1976 and 1977

	1976		1977	
	t/a	t/d*	t/a	t/d*
Newsprint	816	3.3	1038	4.2
Printings & Writings	1469	5.9	1622	6.5
Packaging	5196	20.8	7670	30.7
Industrial	181	0.7	260	1.0
Tissues	103	0.4	139	0.6
Boards	350	1.4	365	1.5
Coated paper	656	2.6	1322	5.3
Waste paper	408	1.6	502	2.0
Total	9177	36.7	12917	51.7

\* Assuming 250 working days per year

Source: Customs and Excise Report for 1977(22)

writings will continue to be imported as finished articles), or several 1 t/d mills specialising in high quality industrial, printing and writing, or tissue paper or boards. Newsprint produced from mechanical woodpulp is so cheap that it would not be worthwhile producing on the island on a small scale from bagasse.

Now consider the possibilities for export. How can the world and regional markets for pulp and paper be characterised? Recently, many paper mills in developed countries have been closing, or reducing production, despite a still increasing market for paper. This can be considered as the result of the construction of many new pulp mills in developing countries with government and international support, while the market for paper did not grow as fast as anticipated. An alternative explanation given by Western considers this as the result of technological determinism(16,pp.26-7).

"After a lull in the paper machine manufacturing industry



during World War II, engineering progress was accelerated and shortly afterwards the race for even more width and speed was resumed. The inventions previously mentioned in Chapter 1 assisted and by the early 1960's widths of 9 metres and speeds of 700 metres/minute were achieved. Then the consequences of such development began to manifest themselves. Capacity exceeded consumption and paper prices slumped. The widths and speeds began to require sophisticated and expensive controls for efficient operation, still further adding to already disproportionate machine costs, which were no longer compensated by increased paper prices because these were set by the mass of earlier, written-down machines still in operation. From 1930 to 1975, the cost/annual tonne of a newspaper machine increased at least forty fold while the price of newsprint increased less than twenty fold! A strange progress this. The installation of new machines became a luxury which could be afforded only by multi-national giants or the government (sic) of developing countries, advised by consultants that only scale to this degree could be economic! For the consultants it was economic; they were now essential for large mill design and coordination.

Alternatives could not easily be considered. The enormous investment in large machine tools locked the major machine suppliers to the unprofitable giants. The sheer cost of the money involved for a new mill now exceeds in many cases the margin between production costs and revenue. The situation has become (sic) uncontrollable and paradoxical in that, despite steadily growing demand, paper manufacturers, with few exceptions, cannot afford to renew their equipment! In many cases, they have chosen to upgrade it by modifications producing paper grades with greater margins of profitability, leading to the closures of many smaller mills not necessarily for price reasons but by market control. No new machines, except for tissue or speciality papers has been built in England since 1960 and the decline in production overall has been met by imports. The same applies to other developed countries and this outcome should be a lesson to the developing world.

Whatever the explanation for the current overproduction of paper, the fact remains that no country can hope to succeed in a new export pulp or paper mill unless it has abundant supplies of cheap raw material, energy and chemicals. In this respect Mauritius is disadvantaged by its high energy prices, as a large scale pulp mill will require fuel both for the mill and to replace the bagasse in the sugar factory.

Add to this the effect of the high cost of transport from Mauritius, the only prospects for large-scale export of pulp from Mauritius would be to regional markets. Such markets might be the increasing paper consumption in East African countries, or India.

Unfortunately, many African countries are establishing large pulp mills based on their forest reserves and plantation projects, such as the IFLOMA project in Manica in Moçambique.

The Indian market has great potential, as the present consumption is one of the lowest in the world at 1.8 kg/a per capita, compared with 30 kg/a in Britain in 1900 and 100 kg/a for most developed countries today(16,p.19), or 10 kg/a in China and 20 kg/a in Malaysia(16,p.52). Western writes, " it seems clear that the present low levels of paper consumption are indicative more of import restrictions and lack of investment than absence of demand and this view is supported by evidence In other words, today is a seller's market."(16,p.52) The official estimates of additional annual capacity requirements, at a conservative 7% annual growth rate in consumption, are for 1.4 Mt by 1983/4 and 2.4 Mt by 1988/9(16,p.57).

This promising market has one drawback; no imports of paper are permitted except for newsprint(16,p.4). So, anyone who intends to export, to India, any pulp or paper other than newsprint needs good Indian contacts. In practice, this means that Indian investors would have to be involved in the establishment of the mill, as they would be able to put the necessary pressure on the Indian government to waive import restrictions. Therefore, producing bagasse pulp in Mauritius for export to India might be an attractive proposition to a well connected Indian businessman, but an impossibility for Mauritian

businessmen or the Mauritian government.

To summarise, it would seem very difficult for a Mauritian-owned large-scale pulp mill to export pulp or paper in sufficient quantity. It would be possible, however, for Mauritian entrepreneurs or cooperatives to start mini-mills to supply the local market - but would these be profitable? To check on this, cost-benefit analyses of two types of Indian mini-mill have been carried out.

### **3.1. Cost-benefit analyses of Indian mini-mills under Mauritian conditions.**

Appendix 4 gives full details of these calculations; what follows is a summary of the method used and the principal results.

Two sizes of mini-mill were considered, a 15 t/d mill, as considered previously in this chapter, based on the costings of Western(16) and Rao(17), and a handmade paper plant of 400-1200 kg/d capacity based on a project description supplied by Coromandal Hydraulics, manufacturers of handmade papermaking equipment(23).

The Mauritian prices were taken from the 1977 Customs and Excise report(22), the Bi-annual Survey of Employment and Earnings(24), the Central Electricity Board report(25), a Development Bank of Mauritius report(26), and 1977 costs of certain items at factories visited by the writer. These prices are set out in figure A4.3 in appendix 4. Where no Mauritian price was available, e.g. for papermaking machinery, Indian prices were used, with a margin for freight costs for items that would be imported from India.

As the purpose of these analyses is to determine whether such mini-mills could be beneficial to the economy of Mauritius, rather

than just an investor<sup>#</sup> these costs were multiplied by accounting ratios as described by Scott(27). His ratios calculate the equivalent foreign exchange costs of Mauritian purchases, and allow for the social benefit of employing previously unemployed workers. They do, however, assume that the exchange rate reflected the true value of foreign exchange to the Mauritian economy. Although this was true in 1972, when he wrote his report, by 1977 the current account deficit had reached Rs512 M(28), and, in 1979, the rupee was devalued, so it can be argued that in 1977 the rupee was overvalued, and that a different shadow exchange rate should be used. Therefore, a second set of accounting ratios were calculated, based on an accounting ratio of 1.2 for foreign exchange, instead of 1.0 in the original. These ratios are detailed in figure A4.1 in appendix 4. In the following tables, results calculated on an accounting ratio of 1.0 for foreign exchange are indicated by the letter A and those based on a ratio of 1.2 by the letter B.

For the 15 t/d mini mill, the results of this calculation are detailed in figure A4.4 to figure A 47 in appendix 4. These are summarised below in figure 6.10 to figure 6.13.

The range of production costs allow for the possibilities of using imported pulp or imported textile wastes (cheaper) as a source of long fibres, and the alternatives of generating steam, all year round, from an oil-fired package boiler or using steam from a sugar factory for a third of the year.

Whereas a 15 t/d mini mill would not be as economically rewarding in Mauritius, as some of these mills are in India (with internal rates of return of 34%(16) ), they are nonetheless interesting at the

<sup>#</sup> Financial analyses from the investor's viewpoint are given in appendix 4.

Figure 6.10 Capital cost of a 15 t/d pulp/paper mini mill in Mauritius at 1977 shadow prices.

(kRs)	A	B
Buildings	1692	1922
Plant & equipment*	16267	19119
Spares (2% of above)	325	382
Vehicles*	59	69
Office equipment etc.*	146	172
Pre-operation costs*	694	775
Sundries*	702	741
	19886	23180
Contingencies (5%) and technical fees (2%)	1392	1623
Total capital cost	21278	24802

A - using accounting ratios from column A in figure A4.1.

B - using accounting ratios from column B in figure A4.1

\* - from Indian prices.

Figure 6.11 Unit production costs for a 15 t/d mini mill at 1977 Mauritian shadow costs.

Item	Cost/(Rs/t paper)	
	A	B
Fixed costs	479	515
Chemicals	1054	1237
Fibrous raw materials	826 - 722	960 - 837
Services	1122 - 1019	1297 - 1181
Total production cost	3481 - 3273	4009 - 3770

A - using accounting ratios from column A in figure A4.1.

B - using accounting ratios from column B in figure A4.1

discount rates favoured in the Jamaican study(10), Scott's 1972 report(27), and at the December 1977 commercial bank prime rate(28) - respectively 7%, 5% and 8%.

Such a mini mill, to produce packaging grades, is worth further

Figure 6.12 Unit revenues from paper sales at 1977 Mauritian shadow prices, for a 15 t/d mini-mill.

Accounting ratios -	A		B	
Production cost -	1	2	1	2
Selling price/(Rs/t)	4186	4186	4914	4914
Prod'n. cost/(Rs/t)	3481	3273	4009	3770
Net revenue/(Rs/t)	705	913	905	1145
Annual revenues at 4075 t/a /(kRs)	2873	3721	3689	4664

A - using accounting ratios from column A in figure A4.1.

B - using accounting ratios from column B in figure A4.1

1 - using steam from an oil-fired boiler and imported textile wastes.

2 - 1/3 of the steam from a sugar factory and using imported pulp.

Figure 6.13 Discounted cash flow analysis for a 15 t/d mini paper plant at 1977 Mauritian shadow prices.

Accounting ratios -	A		B	
Production cost -	1	2	1	2
Cash flows - year 0	-21.3	-21.3	-24.8	-24.8
- years 1-13	2.9	3.7	3.7	4.7
NPV at i=5%	5.4	13.0	9.4	18.1
7%	2.6	9.2	5.6	13.3
11%	-1.7	3.5	0.1	6.0
IRR	9%	14%	11%	16%

All cash flows and NPVs in millions of Rupees.

study, needing a detailed investigation of the qualities of paper that can be produced at this scale from bagasse using soda pulping or chemimechanical pulping (both of which are used in India), and the production costs of each route. It would pay to place the mini mill adjacent to a sugar mill, in order to make use of a little of the factory's steam during the crushing season, and to make an effort to collect local textile wastes to reduce the imports of long fibres

needed to increase the paper strength.

Locating the factory next to a sugar mill would also reduce the cost of bagasse transport. There would be little difficulty in obtaining surplus bagasse, as the 20 000 t/a required are less than any estimate of the surplus bagasse availability in Mauritius. Although these estimates vary greatly, including values of 123 000 ton/annum dry(5), 22 000 ton wet in 1966 and a potential of 120 000 ton wet bagasse in a normal year(1), and 166 000 t/a dry(6), there should be no problem finding 20 000 t/a wet bagasse for a mini paper mill.

Similarly the  $4500 \text{ m}^3/\text{d}$  required for a 15 t/d plant (at  $300 \text{ m}^3/\text{t}$  paper(17) ) should be available at many sites, including all five mentioned in the Sandwell report (see figure 6.1).

It would not be worth starting such a mill until the full potential of waste paper for packaging paper production is being used, as waste paper requires less costly plant for its pulping and needs less chemicals (or none).

The other cost-benefit analysis is of a handmade paper mill. This is based on a project study provided by Coromandal Hydraulics of Dindigul, South India, which makes use of their cylinder mould vat. This is similar to moulds used in paperboard operation, but designed for hand operation. Its operation is best described in the following quotation from their report(23).

The vat consists of a cylinder mould rotating in a cement concrete tank on ball bearings. Pulp at a steady consistency of 0.25%, to 0.75% is maintained in a cylindrical tank by a rotating paddle agitator and pumped to an overhead box. The level in head box is maintained and pulp flows to the vat by gravity. The mould is immersed  $3/4$ th



in a thin solution of pulp. Because of the difference in the static heads maintained by the pulp outside and white water inside, the pulp rushes into the cylinder draining water and forming a thin layer of wet sheet all over the surface of Cylinder Mould. When the mould rotates the thin layer of continuous sheet formed is picked up by a woolen felt, from the couch roll. The wet sheet is carried by woolen felt over a series of rolls comes to press part and passes between the top metal roll and rubber roll, when the sheet is wound over the metal top roll. The sheet is removed from the metal top roll and sent for drying.

This Vat is manually operated. Two persons rotate the handle. Altogether (sic) per shift 6 to 8 persons are needed. Depending upon the thickness of sheet, 1,500 to 3,000 sheets can be produced in 8 hours shift. Paper of 150 g.s.m. to 1,500 g.s.m. can be made in this Vat. Any variety of paper, drawing paper, white cards, pulp boards for file making, grey cards, grey board, mill board etc. can be produced.

The capacity ranges from 400 Kgs. to 1,500 Kgs. per day of 16 hours working.

The pulp is produced in the usual way of the Indian handmade paper industry, digestion of agricultural fibres in a batch digester with Sodium hydroxide, followed by beating together with chopped rags and waste paper in a Hollander beater. Bagasse is not usually used in such plants, except sometimes mixed with straw in the production of strawboard, possibly the result of having tried to digest and pulp bagasse without depithing and under the same conditions as for pulping straw. As bagasse is pulped successfully by batch digestion with no beating, in mills up to 30 t/d capacity(16,p.87), it should, in principle, be possible to do the same in batch digesters in 1 t/d mills. So, the cost-benefit calculations assume this is so, using the chemical consumption as given by Rao(17) for digesting bagasse, and adding the cost of digesters to the capital costs in the Coromandal Hydraulics report.

These calculations are detailed in figure A4.8 to figure A4.11 in appendix 4, and summarised here in figure 6.14 to figure 6.17.

Figure 6.14 Capital cost of a 400 kg/d handmade paper project at 1977 Mauritian shadow prices.

Item	Cost/kRs	
	A	B
Buildings	225	256
Pulp and paper machinery	154	181
Electric motors, starters and other industrial equip. )	29	34
Office equipment	2	3
Erection	25	25
Total	435	498

A - accounting ratios from column A in figure A4.1

B - accounting ratios from column B in figure A4.1

Figure 6.15 Production costs for a 400 kg/d handmade paper plant at 1977 Mauritian shadow prices.

Item	Cost in Rs/day	
	A	B
Fibrous raw material	180	202
Chemicals	579	680
Labour	638	638
Electricity	192	224
Misc. expenses	49	49
Total	1639	1794

A - accounting ratios from column A in figure A4.1

B - accounting ratios from column B in figure A4.1

To check the effect of the quality of the paper produced, the sales calculations have been carried out twice, once for printing and writing paper, once for packaging paper.

As figure 6.16 shows, the sales price of the paper produced is critical for the profitability of the plant. The profit is reduced to 3%-13% of the profit when producing printing and writing paper if the

Figure 6.16 Revenue of a 400 kg/day handmade paper plant at 1977 Mauritian shadow prices.

	Type of paper sold:			
	Printing and writing		Packaging	
	A	B	A	B
Daily sales (400 kg/d)/Rs	2685	3152	1674	1966
Production cost/Rs	1638	1794	1638	1794
Daily net revenue/Rs	1047	1358	36	172
Annual revenue/kRs	314	408	11	52

A - accounting ratios as in column A of figure A4.1

B - accounting ratios as in column B of figure A4.1

paper has to be sold as packaging paper. This difference is far greater than the differences in net cash flows resulting from different accounting ratio assumptions.

Figure 6.17 Net cash flow analysis for a 400 kg/d handmade paper plant at 1977 Mauritian shadow prices.

(Cash flows in millions of rupees)	Type of paper produced:			
	Printing and writing		Packaging	
	A	B	A	B
Capital cost	-0.44	-0.50	-0.44	-0.50
Annual revenue	0.31	0.41	0.01	0.05
NPV (1+13 years) at 5%	2.4	3.2	-0.4	-0.01
7%	2.0	2.8	-0.4	-0.06
11%	1.5	2.1	-0.4	-0.14
IRR	72%	94%	-14%	5%

A - accounting ratios from column A in figure A4.1

B - accounting ratios from column B in figure A4.1

The effects of this can clearly be seen in figure 6.17, where for all reasonable discount rates the production of packaging paper in this 400 kg/d handmade paper plant yields negative net present

values. On the other hand, the internal rates of return of 72% and 94% for the production of printing and writing papers show how profitable such very small plants could be.

The most profitable Indian handmade paper plants make high quality papers - drawing paper, filter paper, art papers and industrial grades. These are so profitable that Western remarks about one:(16)

N.B. The price is almost irrelevant. For such paper, with 100% cotton furnish, it is about one tenth of that which can be obtained in developed countries for equivalent grades. The whole output can be exported without difficulty. The manufacturer aims at around 25% profit on sales.

Such mills contrast with the cottage-type waste based handmade paper mills which make cheap, sun-dried, boards. Unless run with good production and quality control these mills often run at a loss. This is generally the case in the Sri Lankan strawboard industry studied by de Wilde(29). He showed that, on average, the factories operated at 50 ton strawboard annually, making a loss of Rs23 125 annually on the total capital employed of Rs475 000 (Sri Lankan rupees). They had production difficulties owing to their reliance on sun-drying, and the quantities of chemicals and firewood used varied greatly, as different managers used different process conditions according to their lack of experience. On the other hand well managed factories were profitable, such as Maniyangana which was able to make a profit of Rs46 000 annually.

So, any handmade paper mill in Mauritius would have to aim at producing high quality printing and writing papers and industrial grades, such as filter paper. To do this it would have to make full use of the textile and clothing wastes in Mauritius, and only then see about how it could use bagasse. An investigation of how bagasse

is best pulped in small digesters would be needed, using the soda process or, perhaps, one of the newer processes for digesting agricultural wastes, such as ammonia pulping(30,31). More important would be the design of an efficient moist depither for use on a very small scale, as bagasse paper and board made with the pith included is much weaker, as shown by the sample attached to this thesis. This was made in a Khadi and Village Industries Commission handmade paper mill at Pune, by digesting the bagasse with boiling 2.5% NaOH solution at atmospheric pressure.

Provided a sufficiently high quality paper could be produced from bagasse admixtures, the main problems would not be strictly technical but managerial and social - any potential investor or cooperative would do well to read de Wilde's account as a cautionary tale of what not to do. Describing the background of managers of strawboard mills set up by the Industrial Development Board of Sri Lanka, he says:

None had previous experience in management or supervision or had worked in any form of production-unit or factory. There (sic) education ranged from 8th grade to 0-level

All of them got a training for 1-1,5 month in the IDB to learn the process of strawboard making. But how can one expect people to be managers of straw-board factories if they only understand the principles (not even the practice) of strawboard making?

Such a selection of managers might seem unlikely in Mauritius, but see the chapter on Yeast Producers (Mtius) Ltd. to see a parallel instance (admittedly at a higher level). How the managers are selected in Sri Lanka is described by de Wilde:

The most astonishing practice in this respect is the example of Nalanda: as in several other cases, no tender was put out for the factory, which was undertaken by a friend

of the local M.P. However, his work was certainly not up to the standards required and the concrete foundation for the Hollander beater machine broke immediately after the installation of the equipment. In spite of the fact that this machine, therefore, was unable to work and the calander machine not even delivered, so that it was impossible to produce finished straw-board, the M.P. instructed in three letters to the G.A. and A.G.A. that more than 18 people who he named be employed in the factory. These included the manager who he praised as having two year's experience in management. The management experience, in fact, consisted of the operation of a small one man cooperative retail shop in a small village near Nalanda.

It isn't surprising that such practices by an M.P. provoke reactions. Two days after the elections, with a victory for the U.N.P., the former opposition party, the factory was attacked by 10-15 persons. When they didn't find the manager they ruined parts of the already not working machinery and electricity wiring. Although the Nalanda case is an exception, in all cases, even in the private and semi-private factories there was pressure from the local M.P. to appoint people who were on his employment list.

Such processes of selection of personnel on a political or personal basis are not unique to Sri Lanka, but are evident of the particularist values found in many small communities.

In the specific Mauritian context, such particularism has been the norm. This was seen in the choice of personnel for Yeast Producers (Mtius) Ltd. (see Chapter 4.1, p.154); in the selective recruitment of Sugar Technology Diplomates, from the University of Mauritius; in the queues of people outside the Prime Minister's House, before the December 1976 elections, waiting to be given jobs in the Development Works Corporation(32); in others who were offered jobs loading lorries in return for voting for a particular party; and in the setting of recruitment qualifications with a particular candidate in mind.

Nevertheless, if such selection processes could be avoided, it is likely that a Mauritian mini-mill or handmade paper plant would be



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## CHAPTER SEVEN

### Conclusions

These conclusions are an attempt to further the understanding of the design process (or decision-making process or technology transfer process, depending on viewpoint) which leads to the adoption of appropriate or inappropriate technologies. It is important not only to learn what specific mistakes must be avoided in introducing new technologies to a society, but also what methods can be used to avoid making mistakes. No idealist list of good versus bad technologies teaches the latter. Inappropriate technologies do not wear black hats.

The case studies reported in this thesis can be considered as accounts of the historical processes of the introduction of new technologies. These can be divided into several phases:

- i. Interest,
- ii. Investigation,
- iii. Implantation,
- iv. Interaction, and
- v. Initiative or Inertia.

Firstly, some interest has to be aroused in a new technology, rather than continuing with traditional methods. Then the technology, market, local economic, political and environmental conditions have to be investigated. The technology has to be introduced into the local setting, both embodied (e.g. building a factory) and disembo-

died (e.g. staff and consumer education). Following its introduction, the presence of this new technology interacts with its environment leading to problems (e.g. lack of sales, pollution, machinery wear and so on). Depending on the reactions of the principle actors associated with the project, these problems are overcome or the problems overcome the project.\*

These are not mutually exclusive steps, nor need they occur in this sequence every time. This list serves merely to provide a framework for the following synthesis of the results of the case studies.

### 1. Interest in new technologies.

For most of the time, most people are quite satisfied with a traditional technology. Examples of this are: cane spirit production in Mauritius; using low pressure boilers in Mauritian sugar factories before the 1970s; and importing goods which could be produced locally (such as boards, yeast, and packaging paper in Mauritius).

When producing cane spirit for local sales on completely depreciated equipment, and selling at high profit margins, there is no incentive for owners of distilleries to invest in new equipment or even <sup>to make</sup> modifications to old equipment. In Mauritius this was compounded by the fact that the groups of companies which run the distilleries (WEAL, Harel Mallac and Denoncla) have many other interests, consequently the distilleries are of marginal concern. Also, the ownership of the distilleries was in the hands of a distillers association, which included all the former owners of distilleries which have since been closed. These companies receive their dividends for doing nothing.

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\* This is different to the more common analysis of a longer term cyclical interaction between society and technology, in which a technological innovation affects the society, which affects future technological innovations.

In such circumstances it is not surprising that, when Vogelbusch representatives came to Mauritius, looking at the possibility of selling their equipment to set up a new distillery, and told the Mauritian distillery owners that they would have to spend money, Vogelbusch were told that the Mauritians did not want to spend money, <sup>as</sup> they produce and design the equipment, <sup>^</sup> they could locally. M. Radar even went as far as to publish an article, in "Le Cerneen", arguing that Mauritius was better off exporting molasses(1). Such arguments hold little force, for improvements to distilleries or new ones cost money whoever builds them, while potable spirit production was certainly more profitable than exporting molasses. Rather, these arguments should be seen as justifications for decisions taken on other grounds, namely that it was not in the interests of the owners to invest more money to produce the same cane spirit which they were already selling profitably. Only when Gilbeys set up their own distillery in Mauritius were they shaken from this complacency.

On the other hand, the managers of the distilleries were, in general, innovative and interested in possible improvements to their distilleries. This was probably a result of the boredom of what is a routine job. This led to the establishment of profitable sidelines, such as the production of perfumes from local alcohol and imported essences, and the preparation of Ricard at O.K. (Solitude) Distillery. But for any major changes the approval of the directors would be required, so here was a source of potential conflict. In general changes were not approved, unless some external factor compelled this. The planned closure of Solitude sugar factory was one such, as O.K. Distillery depended on the factory for its steam, and led to the Harel Mallac group investing in a new distillery at Beau Plan sugar

factory.

The effect of this complacency, upon the managers, was that they investigated problems, such as vinasse disposal, knowing that there would be little chance of getting any investments approved. Knowing this, they would investigate the problem less seriously, each on his own, in ignorance of what the others were doing. Nor would they involve the University of Mauritius or the MSIRI, as this might provide a solution which would cost money to implement. Under these circumstances it is better to play at researching anaerobic digestion, pretending to be solving the problem of vinasse pollution, than invest in commercially available incineration systems, or in the production of fodder yeast.#

A comparable case was that of the plywood importers in Mauritius. As importers they had good profits, did not need to make any marketing effort. They could externalise transport and information costs, as customers would come to them in Port Louis to buy their building materials, and it was up to the customer to discover how to use the materials. So, they were not interested in changing from this traditional activity, and so it was outside this group that interest in producing board locally arose.

Against a background of a general acceptance of the traditional industries and traditional technology, certain people and groups of people become interested in industries, or products, or technologies hitherto unknown in their location. In pursuing these interests they become change agents.† Examples of these change agents are Maxime Raffray ("Top Board"), Jean Rey (bagasse briquetting in Mauritius), Daniel Lagesse (Packaging Industries Ltd.), Raymond Raffray (boiler

# This can be compared to the activities of some of the project managers studied by Hirschman, when they were under pressure from outside interests.

improvements at St. Aubin sugar factory), Maurice Paturau, managers of the Taiwan Sugar Corporation (Pingtung pulp mill), the Anchor Yeast Co. Ltd. (Beau Champ yeast factory) and Samora Machel.

The roles of Maxime Raffray in the formation of the Universal Board Co., of Daniel Lagesse in the Mauritian packaging paper from waste paper factory, of the Taiwan Sugar Corporation management in the studies which eventually led to the erection of the Pingtung pulp mill, of Maurice Paturau in the MSIRI committee that reported on the utilization of sugarcane by-products, and of the Anchor Yeast Co. of South Africa in leading Beau Champ to set up a bakers yeast factory have already been discussed. Jean Rey, as Managing Director of the Mahebourg Lime Co., became interested in finding an alternative fuel for the lime kiln, due to a shortage of firewood in Mauritius. This caused him to look at the production of briquettes from bagasse. Raymond Raffray's interest in the machinery in his factory led him to the idea of improving the thermal efficiency of the factory by installing larger, higher pressure boilers and a turboalternator to generate electricity for factory use and export to the CEB. As this was seen as a straightforward technical decision, taken every time equipment is replaced in a traditional industry, there was not the potential for conflict between management and ownership which there was in the distilling industry.

It is difficult to find common characteristics in these often highly individual actors in the drama of industrialization, except for a negative one—a dissatisfaction with the traditional industries and technologies, linked to experience outside their country to show them that things could be otherwise. An awareness of the existence of alternatives. Samora Machel has emphasised, in many speeches, the

† The term change agent, taken from the rural development literature, is used rather than entrepreneur, as the person who has the idea need not, necessarily, be the same as the one with capital, or be involved with more than the first stages of the introduction of the technology.



necessity for people to compare Moçambique with the developed countries they hope to join by 1990, rather than be satisfied with a level that is "good enough for Africa".

A possible exception to this is the way interest was aroused in Mauritius about bakers yeast production. There was no local change agent, this role fell to a South African company, Anchor Yeast Ltd. They indeed stimulated the Mauritian sugar factories to think of the possibilities of using new technologies, in this case to produce yeast. In this way they acted as change agents. Yet, as actors from outside the country of application of the technology, their role was somewhat different, since they only had to sell their equipment, not make a success of the whole venture.

The difference between these change agents and the others who were content with traditional technologies was that they reacted to the same concrete conditions with a greater awareness of what might be possible, and a greater confidence in their creative abilities.

## **2. Investigation**

Once an interest has been aroused in technologies other than those traditional in the location, the principle actors have to investigate the possibilities. Often this is done poorly, not only in the accountant's sense of a poor financial appraisal, but also by not investigating all the possible interactions between the project and its environment: for example, marketing, the consumers' reactions to the product, the effects of company structure on decision-making, taking for granted traditional methods of staff recruitment and training, effects on food production, cartels and corruption, and, above all, potential conflicts of interest between interested



parties.

If the project inaugurators were involved in production in a traditional industry, they will naturally tend to ignore marketing operations, and conduct cursory market surveys.<sup>‡</sup> In the feasibility studies for the Universal Board Co. and Yeast Producers (Mtius) Ltd., only the total market demand within Mauritius was studied. Inadequate attention was paid to the thicknesses of boards sold in Mauritius, or to their usage, and none at all to the possible consumer reaction to boards which could not be nailed or screwed together in the same way as plywood. No survey of end users was undertaken, so the company had no idea of the users requirements.

The original market survey for Yeast Producers (Mtius) Ltd. was limited to checking import statistics for Mauritius and some Indian Ocean countries, for which statistics were available. No attempt was made to visit these countries to check whether the importing agents were tied to particular suppliers, on how many agents there were, on tariff barriers or on specific local prices. Nor were the Mauritian bakers visited to find out the quality, quantities and price of the yeast they required. Only in 1977 did they carry out a full market survey by interviewing every baker on the island to discover the bakers' opinions of the different yeasts, the quality required and why the bakers preferred to pay Rs12/kg at M. A. Cassim rather than Rs9.50/kg for Mauritian yeast. This delay, and the skimpy initial market surveys, can be seen as a consequence of the experience and interests of the Deep River - Beau Champ S. E.'s directors. They were more experienced in production (as sugar marketing is undertaken by the Mauritius Sugar Syndicate, not the estates), and were, therefore, more concerned with the production of yeast and getting the factory

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<sup>‡</sup> This is clearer in these Mauritian studies than in many previous studies, as Mauritius is an open market economy, in which efficient marketing would be expected.

built at their estate, than with the marketing. This attitude was reinforced by the sales pitch of the Anchor Yeast Co., whose representatives minimised the difficulties of marketing.

Hirschman(2) might say that the Anchor Yeast Co. were believers in the "Principle of the Hiding Hand", deliberately compensating for a Mauritian underestimation of their problem-solving competence by an underestimation of the difficulties. I would suggest that their motives were akin to those of the sales engineers described by Hesch(3):

I remember one plant in the North East of Brasil, where the managing director of the company purchased the cheapest installation, which had been quoted to him. He finally got what he was paying for: cheap, fragile, partly old fashioned machines, sold by a couple of smart and ruthless sales engineers. I worked for a while as trouble shooter in this plant and had to tell to the company that the only chance to save the project was to replace almost the whole preparation line for chips up to the gluing machines. After two years of losses the company was not able to do so any more and went bankrupt.

Outside Mauritius, the effects of poor market surveys can be seen in the experiences of the Hulske particleboard factory in South Africa, the Kisumu alcohol factory in Kenya (in its projected sales of citric acid and yeast), and on the market size projections which caused the Edfu pulp mill to be built with a large recovery plant for early expansion (see literature survey).

Better approaches to investigating the market were taken by Lagesse, Rey and the Taiwan Sugar Corporation. Lagesse studied the market opportunities in Mauritius before choosing his industry, and then chose to produce the grades of paper in the greatest demand, in quantities which would not exceed the market demand. Rey had a guaranteed market for 5000 t/a bagasse briquettes in his lime kiln,

and in a contract from the Bois Cheri tea estate, before he began. In fact, the problems in this case were derived from an inadequate study of the production technology rather than the marketing.

In both this case and that of Yeast Producers (Mtius) Ltd., the directors of the Mauritian companies were totally dependent on foreign suppliers for their technical information, and made no attempt to evaluate critically this situation by contracting local, or independent foreign, consultants. Certainly, there were microbiologists\* in Mauritius who could have seen the folly of having no filter on the air intake, or the effects of overheating the yeast in the drier, and food technologists# who could have pointed out the alternative of a pressed yeast factory. And, as Rey was dependent on the Pawert-SPM engineers (as there was no-one in Mauritius had had experience of high pressure briquetting machine), there was no one to point out to the Swiss engineers, inexperienced in bagasse use, that Mauritian bagasse was different to that in Hugot's factory (where SPM Group Inc. had installed a successful bagasse briquetter).

The absence of any local investigation of the technologies often leads to uncritical acceptance of whatever is proposed by an equipment supplier or consultant. This is most evident in Sangster's(4) uncritical acceptance of the OAS study on paper, animal feed and alcohol production in Jamaica(5). As has been shown in this thesis, there are alternatives available which have not been considered by Proenza et al, such as Indian mini-mills for the production of chemical pulp and paper. Also, it has been shown that, although the Indian designs are best adapted to Indian conditions, these technologies

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\* e.g. Gerald de Senneville.

# e.g. Thierry Sik Yuen.

could be potentially profitable even when transferred to higher wage developing countries such as Mauritius.<sup>6</sup>

Such uncritical acceptance of received wisdom can lead to the abandonment of projects when the preordained technology could not be economic in the conditions of the recipient country, and, conversely, to the construction of inappropriate plants, such as the dried yeast factory in Mauritius. In the worst case, this trust of the supplier can be disastrous, as in the following example, quoted from Hesch's letter(3):.

In the Caribbean I have been expert for the arbitrage in a project. Here a rich man who thought he had gathered sufficient knowledge on this specific field signed a contract, as I was told, in a bar around midnight, on a project of about 12 million DM, which turned out to be worth less than 6 million DM. In this case not the slightest chance existed to save the project.

The point stressed here is that local expertise outside the promoting group should be used to investigate the technology to be used, supported by independent foreign expertise where necessary.<sup>7</sup> Such a procedure was followed by the Taiwan Sugar Corporation when planning a new pulp mill. Firstly, local consultants were contracted to investigate the possibilities, making full use of their knowledge of the local conditions, following which this report was submitted to independent foreign consultants for assessment, particularly of the technical aspects. Subsequently, a project office was set up to prepare the detailed specification, liaise with contractors, and supervise the construction and testing of the plant (among other tasks), drawing on local expertise.

In this way a full technical assessment may be made, with a good idea of how the techniques may be adapted to and applied in local

<sup>6</sup> Certainly economically viable at accounting costs, for both technologies, and potentially profitable to a private entrepreneur, in 1977, for the mini-mills but not the handmade paper plants.

<sup>7</sup> Unfortunately, much of the work of development agencies has been to carry out their own investigations, or encourage the

conditions. However, even this process may be limited by the foreign and local consultants taking a purely technical and/or economic approach to the investigation.

Examples of such less obvious factors which should have been studied before starting these projects are:

- i. The effect of cartels or dominant suppliers on marketing (Mauritian yeast),\*
- ii. consumer reaction to a new product ("Top Board"),
- iii. competition between cash crops and food production (Fuel alcohol from sugarcane),
- iv. pollution (Vinasse disposal in Mauritius and Egypt),
- v. detailed transport costs (Hulskane, Mauritian yeast—it is cheaper to supply yeast to Mombassa from Montreal than from Mauritius),#
- vi. changes in government decisions (Caymanas anhydrous ethanol plant in Jamaica, Sri Lankan strawboard factories),
- vii. potential conflicts of interest between those involved in a project (most of the studies),†
- viii. how the company structure can affect future problem-solving (Universal Board Co.),‡ and
- ix. whether friends and acquaintances are the best staff for new industries (Beau Champ yeast and Sri Lankan strawboard factories).§

equipment manufacturers to do so, to design more appropriate technologies, rather than strengthening the local capabilities to do this, denying the users of the technologies an opportunity for learning.

\* Clearer in this case than in others previously studied

# Such disadvantages of "sea-locked" economies have not previously been given the attention they deserve, unlike the

This is an incomplete list, made up of only those factors which had an effect upon the cases studied here, and which could have been investigated before the decision to order equipment was taken. As these were not, the questions to be answered are: Why were they not investigated? How were the design decisions reached?

In all the Mauritian cases (and possibly elsewhere) the investigation was carried out by one man, or a small group of men within a company who, in general, avoided involving other Mauritians in the investigation phase. As a result, most of the investigations tended to concentrate on some areas at the expense of others—through their inexperience in certain matters, through being constrained in negotiations through technological or financial weaknesses and through following practices socially acceptable in their Franco-Mauritian community.

Except for Lagesse, who started by investigating the market conditions, the other groups had little experience of marketing, and so ignored market research. Rey had no experience with bagasse compression, and little of day-to-day bagasse handling, as neither the Mahebourg Lime Co. nor Gaz Industriel Ltd. had had to deal with either. As a result, he, perhaps, was less able to anticipate difficulties in the production of bagasse briquettes, which combined with the chance that Pawert-SPM had sent an engineer inexperienced in bagasse handling to design the plant.

Maxime Raffray had no choice about distribution policy for "Top Board", as he had to raise capital from the plywood importers who, in return, were appointed distributors. The directors of Beau Champ S.E. also had no say in the design of the yeast factory, since they equivalent problems of land-locked regions.

† Considered by Hirschman and de Wilde, but not given sufficient attention elsewhere.



had not the technical knowledge to check the affirmations of Anchor Yeast Co. Because of this technological dependence they were also constrained in their financial negotiations. Consequently they had to import all the equipment which could not be made in Mauritius from South Africa, even when the equipment was originally manufactured elsewhere, and they had to pay for this while still waiting for the Anchor Yeast Co. to put up their share of the equity.

Specifically Mauritian factors (although with possible parallels elsewhere) were the appointment of staff at Yeast Producers (Mtius) Ltd. and the behaviour of the "Top Board" distributors. In the former, a Franco-Mauritian practice has been to appoint staff always from this community, where possible, and preferably from the same company.§ For this reason, an agronomist-turned-factory chemist at Beau Champ, Serge Duvergé was appointed manager of the yeast factory, and not a microbiologist or food technologist. The "Top Board" wholesalers were primarily importers, and hence sold "Top Board" as if it were a standard, well known, imported product.

### 3. Implantation

This refers to the stage from the signing of contracts to the beginning of operations. Here one has to focus on what is transferred to the new environment and what is not. Is it just the machinery (embodied technology) or the complete system of social relationships which are required to make the project succeed (the disembodied technology).

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§ Shown by the difficulties experienced by non-Franco-Mauritian diplomates in sugar technology of the University of Mauritius in obtaining employment in the sugar industry, (except after some years work elsewhere).



In none of the cases studied in Mauritius did any of the machinery fail to arrive, unlike some of the secondhand pulp and paper machinery imported into India for mini-mills. "Misadventures of mini mills" reports how several inexperienced Indian entrepreneurs started frantic searches for missing parts when their equipment arrived(6). The only secondhand machinery used in any of the Mauritian projects were a briquetting press from Madagascar and 90% of the pulping and papermaking machinery in Packaging Industries Ltd.. Pawert-SPM provided the spares necessary to renovate the briquetting press, and Lagesse went to see most of the secondhand equipment before ordering it, so there were no problems in the transfer of machinery to Mauritius. Indeed, some of the equipment was constructed in Mauritius, such as the growth tanks for the yeast.

At the next level, the staff training must be considered, for machinery, however good, will not work without trained staff to run it. Yeast Producers (Mtius) Ltd. provides an excellent example of how the knowledge of the staff can affect the functioning of a technology.† For after training by Anchor Yeast staff, the Mauritian factory produced yeast with poor keeping qualities, yet after training by engineers from Lallemand Inc., the factory produced yeast with excellent keeping qualities. The training provided by the two companies was different in both content and and the method used. The South Africans taught a technology which was adequate for their own conditions (where yeast could reach the consumer in a month), but not for export sales where yeast could be in shipment for four months. The Canadian company already produced yeast for export, and based their work on Mauritius on their detailed knowledge of the growth of yeast. Their approach was to conduct experiments in the Mauritian factory

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† Indeed, a unique real life experiment which allowed two training methods to be compared in the same factory and on the same people.

together with the local staff, seeking to improve the fermentation and drying conditions while using the same equipment. In this way the Mauritian staff learned not only an improved process, but also how to conduct their own experiments to improve the process (as they did later to increase the production capacity). They found that after the experiments they understood better what was happening to the yeast, rather than blindly following instructions to keep the pH to such a level, the air flow to this level, and so on.

In contrast to this, the staff at the Universal Board Co. were well trained (Siempelkamp GmbH engineers), and well qualified (one was a Diplome in Sugar Technology from the University of Mauritius), to the extent that they were able, unaided, to adapt the process to produce 4 mm particleboard after two years of experimentation. Similar results were achieved at the Pingtung pulp mill.

Given a working plant with trained personnel, it is not sufficient to say that the technology has now been transferred. For the product has to satisfy the consumer, else the factory might as well not be there. The technology of particleboard production in Europe exists in a certain environment in which its product has uses. This environment includes the knowledge and skills of the particleboard users which has been built up after years of user education by the manufacturers. It includes the mechanisms by which user requirements are passed back to the manufacturers via the distributors or directly by contacting the applications or sales departments of the manufacturers.

When the production of particleboard is transferred to a society where it has not been used previously, an equivalent environment has

to be created in this society<sup>§</sup> As Bassili(7) emphasised:

In certain instances production started and boards were delivered to the distributors without any measures being taken to educate the salesmen, let alone the end users, on the properties, correct applications and limitations of this new product.

Whereas in the developed countries producers financed national promotional associations, local mills in the developing countries very seldom did so. Since neither the present nor the future users of the product (carpenters and students in vocational schools) had any idea on this topic, they assumed (and who can blame them?) that wood based particleboard was, as its name implies, a new form of wood. Consequently, they loaded shelves with higher loads than acceptable and placed screws for hinges in edges, etc., leading to the foreseeable consumer resistance to the product, once it had failed to perform as expected.

Another important, yet often neglected, aspect is that the designs and technical specifications of the locally produced items like school and office furniture, kitchen cabinets, partitions, etc. that hitherto used sawn wood and plywood, were not modified to allow the use, where appropriate, of this new product. On similar lines attempts at modifying the Building Codes—where they exist—to allow for the use of particleboard have often not been pursued with enough vigour to assure a successful end result.

Another point worth considering is that only in a few instances have measures been taken by the industry to import or produce locally, the special metal and plastic hardware which have been developed specially for particleboard in the advanced countries and which have no doubt greatly contributed to its fantastic growth in these countries.

As has been shown, in Mauritius none of these points was considered. Such "parachuting" of particleboard factories into developing countries without any attempt to establish a sympathetic environment for the use of the product have been all too common. Occasionally, after the company has gone bankrupt, it is bought out by another company which starts marketing and user education from scratch. Such happened at a factory in Thailand, where the machine suppliers took the money and ran. When carpenters attempted to use this product it blunted their saws. With no idea of how to make use

§ The problems of the transfer of a disembodied technology into a different social environment has been discussed by others. The dynamics of this, and the dynamics of the establishment of new social mechanisms to embody this, have not.

of this strange material they stopped buying. Within six months the sales collapsed. When the factory was taken over by a new company (Thai Chipboard), they started a training school, where they gave short training courses on particleboard applications to all their customers. They also started producing flush doors in their factory, as it was easier for them to do the cutting and veneering, and then leave the assembly of the doors in their frames to the local carpenter. There was a good demand for the doors(8).

Similar efforts were undertaken by the United Africa Company to promote its particleboard production at Sapele, Nigeria. They show films, arrange meetings and exhibitions and produced a technical manual, all to show the users how they could best make use of particleboard(9). The manual gives the technical description and specification of their particleboard, information on storing, machining, covering the edges and finishing the sides, joints, special fixings, cutting, painting and varnishing the board, and guides to the design of furniture, partitions, ceilings and floors for particleboard(10). In the opinion of the promoters this particleboard plant is at the moment 3/4 successful, and all this effort in user education and a sufficient discount on the plywood price were necessary to get to this stage(9).

Although the promoters of these projects describe this user education in terms of promotion of a product, in fact the change required is greater than just persuading people to try a product, for the work practices of a section of society have to be changed so that they can use the product. Such "promotion" aims to achieve social change,<sup>⊕</sup> and, as such, is trait-making in Hirschman's terms. It is these social relationships between manufacturer and consumer which

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⊕ The necessity of social change in consumer attitudes has long been accepted by advertisers of consumer goods (see Medawar(15)), but not rarely considered by those studying the production of durable goods.

are critical to the success of the technology of particleboard manufacture, so critical that they can be said to be part of the technology, as nowhere are particleboard plants successful without these changes among the users.

#### 4. Interaction and Initiatives

Once production commences, interactions occur with the social, economic and physical environment where the project has been implanted. These can lead to unforeseen problems which require some initiative to solve.

The interactions depend on the society in which the project has been located, and the previous history of the project. The investigation phase is carried out just so that as many eventualities as possible can be foreseen. The implantation is intended to set in motion all the forces that will be needed to overcome problems which may arise later - forces such as marketing organisations, user training, political lobbying and process development.\*

Examples of effects of such interactions are:

- i. Volcanic ash and silica in Mauritian bagasse acting on the pressure seals in the briquetting machine led to rapid wear of the same,
- ii. Wild yeasts growing in cane fields, sucked into the air intake of a bakers' yeast factory led to infections and low yeast yields,
- iii. Yeast shipments from Mauritian to Indian Ocean countries interacted with a transport system designed to transport goods

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\* Or rather, ought to be so. Frequently those involved have a static view of technological development, and so do not do this. This is not surprising, as most people who have studied the introduction of new technologies take an equally static, and linear, view.

- to and from Europe, S.Africa, and Singapore, leading to high transport costs and long delays,
- iv. These long delays interacted with the keeping qualities of yeast produced to South African standards, leading to inactive yeast being delivered to the consumer,
  - v. A market demand for thin 4.5 mm boards was incompatible with the design of a 2-opening press particleboard plant,
  - vi. The properties of particleboard interacted with the methods used by small furniture manufacturers to produce bent boards, screws pulling out of end grain and worn saws, leading to low sales,
  - vii. Old distillery designs which ignored pollution, interacted with more and intensive land and water use and lower tolerances for pollution to produce a worrying problem for distillery managers (in Mauritius <sup>and</sup> <sub>^</sub> Egypt),
  - viii. The interactions between Clostridium <sup>aceto-</sup> <sub>^</sub> butylicum, molasses substrate instead of potatoes led to lower yields and increased risks of infection in the Hawamdieh acetone-butanol distillery in Egypt,
  - ix. An inadequate bagasse feeder interacted with a depithier at Pingtung pulp mill to produce irregularities in the feed to the depithier and consequent variations in performance,
  - x. The interaction between the anhydrous alcohol project in Jamaica and the political environment (namely a desire to maintain government revenues), led to the withdrawal of excise duty guarantees, and



- xi. The interaction between Sri Lankan elections and staffing at strawboard factories led to substantial changes in personnel after elections.

What is interesting is not how such interactions occur, but the reactions of the principle actors involved in the project. Are they seen as problems? Is the response that of initiative or inertia? For Hirschman(2) suggests that problems lead to problem-solving initiatives (as long as they are not encountered too early in the project life) which give the problem-solvers the confidence to tackle further problems.

Yet, very often nothing (or very little) is done. This can be seen with respect to the malfunctioning of the bagasse briquetting presses on Mauritius, vinasse pollution at St. Antoine sugar factory (and, to a lesser extent, at the other distilleries studied), export marketing problems of bakers' yeast and the marketing of "Top Board".

In many cases we come back to the matters focussed under the heading "Interest" - which groups involved had an interest in taking initiatives on a problem, and which groups had an interest in doing nothing.#

It has been shown in the relevant chapter that neither the plywood wholesalers nor the St. Antoine sugar factory had any interest in increasing their shareholdings in the Universal Board Co. in order to finance improved marketing and user education, as long as they continued to receive more money from the company as fees or margins than as dividends, and they thought that the company was likely to fail anyway. Thus, any initiatives taken by Raffray were foredoomed by the inertia resulting from the conflict of interest between the

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# Even Hirschman did not consider the important effect of group interests upon problem-solving activity, as opposed to the creation of the problems themselves. Certainly no one else has.



different shareholders.

Similar conflicts of interest, between the Savannah Sugar Estates and Mahebourg Lime Co., hindered the resolution of problems in the Southern Bagasse Co. # When the briquetter started to operate for the first full season in 1980, it had maintenance problems (particularly wear on the oil seals, putting oil on the bagasse), problems with the drier, as the flue gas temperature when delivered to the drier was only 200 °C instead of 248 °C so that the bagasse moisture was not reduced to below 12% as needed for the consolidation of the briquettes, and problems with the screw feeder not adapted to coarse Mauritian bagasse. The maintenance was entrusted to the technicians of the Savannah sugar factory, who wished to know whether they were working for the Southern Bagasse Co. or Savannah S.E(11,12).

It seems that the maintenance contract did not cover modifying the briquetter, and the investment by Savannah was so small in comparison with their own interests in the sugar factory that they preferred their technicians to work on the sugar factory. So no initiative was taken to resolve the problems, until the manufacturers agreed to take back the plant to sell it elsewhere(13)\*.

The relative inertia of the alcohol distilleries when faced with a vinasse pollution problem has already been discussed.

There is one example of inertia when faced with problems which cannot be put down to conflict of interests. This was Yeast Producers (Mtius) Ltd. In this case, faced with the absence of sufficient

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# The company set up to produce bagasse briquettes with bagasse from Savannah sugar factory.

\* This is not to say that the Mauritian technicians would have got the press working, merely that no-one tried.

in-company knowledge of how to solve their marketing problems, they sought a foreign company to do it for them. The factory was unaware of any yeast quality problems until the Lallemand engineers arrived. Although calling in Lallemand can be called taking an initiative (and was as successful as it could be under the circumstances), it was a somewhat passive initiative compared to the effort of, for example, the marketing consultant who turned round Floreal Knitwear. In other words, the actors involved did not try to take any initiative which made use of Mauritian expertise, nor even to search for independent consultants who could help—their vision was limited to finding another yeast company to bail them out after Anchor Yeast Ltd. had left them with the problems.

Considering now the initiatives that were taken: the modifications to the Pingtung pulp mill by Taiwan Sugar Corporation engineers to make the depithier function at 100% of capacity; the adaptation of the Siempelkamp pressing line to produce 4 mm particleboard at the Universal Board Co.; the cultivation of strains of Clostridium<sup>aceto-</sup>butyl-icum better adapted to molasses substrates by the staff at the Hawam-dieh acetone-butanol distillery; the user education initiatives at Thai Chipboard after the factory had already shut down once for lack of sales; the Mauritian yeast market survey carried out in 1977; and the compositing of bagasse with vinasse at Médine distillery: show that local initiatives can be successful, provided that the innovators are given the freedom to follow through their ideas, without being held back by other interests.

## 5. Synthesis

This division of the introduction of a technology into a social

environment where it is new, into five phases, is a convenient descriptive device. But, it must not be thought that they are independent. The historical events which occur within each phase profoundly affect and constrain all subsequent phases. It is the dynamics of the process of the introduction of a technology which are important to its success or failure, its costs and benefits, not a particular snapshot at one instant, called "choice of technology", "feasibility study", "project appraisal", "economic review", or, in the chilling words of the title of Raffray's PROSI Bulletin interview, "post mortem"(14).†

The interest phase is important, since it is at this stage that the coalition of interests which will promote the technology is formed. If there are potential conflicts of interest within this group, they will become actual if any problems arise, and hinder problem-solving initiative in the last phase. The particular interests of each actor may also limit the choices available to be considered in the investigation and the measures which can be taken to ensure the implantation of the technology within the society. Finally, the interactions between the project and the other interests of the promoters may actually hinder the success of the project.‡

So any technology, considered as a means to provide a real, felt need, common to many people, has a better chance of success than one which is only clear to one man who has gathered a varied group of interested parties to support the project. Only if it is small enough to be run by a single interest, such as Daniel Lagesse's paper factory, can a single vision stand a good chance of survival.

Here is a limitation to the role of the change agent. Where this

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† The point is fundamental, and distinguishes this analysis from all others.

‡ Directly by creating problems, or indirectly by affecting the response of the actors to the problem.

is one person, who has had an idea, he is limited in his ability to implement it, except on a small scale, by how much it can fulfill the material interests of a larger group of people. The case studies in this thesis show just how much the change agent can be limited in his decisions, in his freedom of initiative, by the interests of others.<sup>§</sup> Indeed, it can be argued that in certain circumstances it is better to introduce a technology on a small scale to avoid these problems, which have been shown to be able to cripple the flexibility of larger scale ventures, irrespective of the economies of scale which may apply to the industry.

The investigation phase, in many of the cases studied, has been incomplete or superficial. Any inadequacies in the investigation have consequences for the design of the technology to be implemented,<sup>¶</sup> and for the interactions of the technology designed on incomplete information with an inadequately understood social and economic environment.\* This leads to the kinds of unforeseen effects and problems which, with hindsight, could have been avoided.

But, change agents rarely have the precognitive ability to foresee all eventualities, so the idealist admonition to take more care with the project analysis has no practical use. Instead, I shall try and draw from these case studies some indication on the methodology which can be used to avoid forgetting to investigate the less obvious, but often crucial, effects. Hirschman talks of side effects as essential requirements(2,p.161). In the particleboard factory case study this is most clear, as user education was not investigated, but was central to the failure of the venture. It was the failure to consider the technological and social forward linkages of the project, in the use of the product, which proved to be the blindest spot in the

§ This is a fundamental problem for development theories which depend on the identification of change agents, and demonstration through them.

¶ Discussed frequently in the literature. \* Not discussed elsewhere.

investigation. In this case, as in some of the others, it was the society which was incompletely investigated, rather than the technical details of production. In Hirschman's terms, no attempt was made to analyse in what ways the technology of particleboard production was trait-making or trait-taking.

Considering the methods of investigation used by the successful projects, and contrasting them with those used in the less successful introductions of technology, certain common factors can be identified. Firstly, in order to analyse successfully the potential interactions of the society and the technology, the investigation must be initiated by, and at least partially carried out by, local people. This may be achieved in different ways. Lagesse personally investigated many market opportunities before he started his personal investigation into the technology of paper production by visiting working plants and talking to both workers and management. The Taiwan Sugar Corporation first contracted a local consulting firm to study the production of export pulp from bagasse. Whatever method is used to ensure a local involvement in the investigation, it protects those involved against complete dependence on equipment suppliers for all their technical information, and the serious consequences of this discovered by Deep River - Beau Champ S.E.\*

Secondly, this investigation should be open to as many different opinions as possible, with reports from one source being submitted to others for comments. In this way, the chances of systematic bias, or of failure to investigate crucial factors, are reduced. For these reasons, the Taiwan Sugar Corporation submitted the report of local

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\* Unfortunately this mistake is being repeated incessantly around the world.

consultants to foreign ones for comment, as the latter would be more up-to-date on the technology, although less familiar with Taiwanese conditions. Many companies do not do this, but keep their studies secret to avoid potential competitors setting up before them. This carries the risk that, in the narrow investigation which is likely to result, crucial factors will be ignored, and later lead to the failure of the venture. This is a far more serious outcome than the possible establishment of competitors. If Beau Champ had consulted local microbiologists, food technologists and marketing professionals, they might never have accepted the deal offered by Anchor Yeast or, if they had, had a better chance of success.

The implantation of a technology in a society is considered here as the introduction of the machinery and equipment, and the creation of the institutions and social relationships necessary for the technology to take local roots. More frequently, technology introduction is rather more akin to a parachute drop, without a survival kit or map, on to an island isolated from the workers, consumers of its product and the interests of its promoters. Certain technologies are implicitly trait-making : particleboard, for example, needs a change in the traditional working practices of the users. To achieve this, a number of institutions are needed, such as training schools, a furniture, veneering and door-making factory, salesmen training, exhibitions, and an advisory service.

A corollary to this is that the design of an appropriate technology must simultaneously consider both the embodied and disembodied aspects of technology. Particleboard production is an inappropriate technology where small furniture manufacturers try to use it like plywood, it can be appropriate when all these small producers



know how to join it with dowels, do their own engineering, and can buy semi-finished articles (e.g. doors) more cheaply than the timber or plywood equivalents.

The interaction of a technology with its environment is the traditional concern of Appropriate Technology practitioners. Such concerns as the environmental and social effects of large projects have been studied, and often classified as inappropriate technologies, as have capital intensive technologies in countries with underemployed labour. As the case studies here were small, they had little impact on their societies, rather the societies impacted upon them.

The impacts in both senses, i.e. the interaction between each technology and its society, were not constant throughout time, but suffered historical changes resulting from the previous decisions in the implantation phase, and from initiatives to modify some of these interactions.<sup>#</sup> It is the dynamics of these changes which needs to be studied, for the very introduction of a technology is a commitment to some change; it is the relationship between the technology and its society, and that between these and human actors in these dramas that determines the direction of change.

In the cases studied, these interactions presented themselves as problems to the principal actors. Their responses to the situation depended upon how well they had solved such problems previously, and to the constraints imposed by the other actors involved. So, in the case of the yeast factory, initiatives were only taken in one limited sense—to find an external source of initiative, just as the very idea to build the factory had come from outside Mauritius. As at no

<sup>#</sup> It is the changing nature of these impacts, the dynamic nature of the interaction, which distinguishes these cases, and this analysis from those traditional in the appropriate technology literature.



point had the Mauritian staff or directors been involved in the design of the plant, they had had no opportunity to take any initiative themselves. Cast into a mould of dependence, they did not find themselves able to think sufficiently independently to resolve their own problems. Only when the Lallemand engineers carried out experiments together with the staff of the factory was their creativity liberated, so that later they could take further initiatives (in changing the process conditions to increase the plant capacity).

It is on this point of creativity that I disagree with Hirschman's "Hiding Hand". He claims that, "Creativity always comes as a surprise to us; therefore we can never count on it and we dare not believe in it until it has happened." This may be true for economists, but certainly to the technical staff who made 4 mm particleboard in a press designed to press thicker board, to the Egyptian microbiologists who reduced the risk of infection in their acetone-butanol distillery, to whoever at Médine distillery discovered that bagasse could be composted with vinasse, this creativity was no surprise. It was necessary in the circumstances. Such creativity is learnt through research; by solving small and then bigger problems. In the case of the introduction of a new technology, it is in the investigation phase that those involved can first practise their creativity, so if this phase is left to outsiders, by the time problems arise there is no-one there who has even thought of how to solve problems in the venture. Also, the implantation is important. If the staff are trained to understand the process and why they do their jobs, and to continually modify it to achieve better performance, they will be able to take their own initiatives when new situations arise. Such was the situation at Beau Champ after the Lallemand

engineers had trained the staff in this way.<sup>†</sup>

One of Hirschman's formulations of his "Principle of the Hiding Hand" is the initial underestimation of the project, so that the actors are faced with these when the project is underway, have to solve them, and do so. Not only is it dangerous because (as he says) if they fail they will be less confident in their abilities to solve future problems, but it is false. It is based on the implicit assumption that creativity is unpredictable and cannot be prepared. Yet, in the cases mentioned, the people involved were able to exercise creativity because of their previous training. And hiding difficulties from those involved in projects misses the opportunities of such training : in the investigation, by practising research, and in the implantation, through training programmes deliberately planned to equip the workers with the ability to use their initiative. Furthermore, his assertion that once a project is well underway the principal actors are committed to it, and have to solve the problems, is not true for directors of private companies who have other interests outside the company. If a promoter hides difficulties from them when getting their support, they may react to the first problems by mentally abandoning the venture—neither pulling out their capital, nor putting in any more to solve the problems, just doing nothing.

To summarise, the introduction of a new technology into a society requires the setting up of a process which will facilitate this. Such a process, to succeed, requires a full investigation of alternative technologies and the society; carried out by local people (but can be aided by specific foreign advice). Through this investigation the technology is designed—both its purely technical aspects, and also all the institutions necessary to make the traits required

<sup>†</sup> The necessity of creativity in the introduction of technologies new to a society has not been stressed sufficiently in the literature on technology transfer.

for the project's success. It is at this stage that all objectives must be explicitly included in the design, not choosing one and then later trying to modify the designed technology to meet objectives of income distribution, for example. The implantation of the technology must be carried out in such a way that all these trait-making institutions are established, including the trait of staff creativity. If the process of technology introduction is so established, then the ability of the actors to deal with the unforeseen is enhanced.†

A technology developed by means of such a conscious process is more likely to be appropriate to the circumstances than one merely chosen on the basis of a list of criteria and then left to develop as it may. How appropriate it is will depend on the depth of the investigation and the explicit objectives of the project. This process does not guarantee that the objectives will be chosen wisely, it merely attempts to improve the flexibility of the project, and reduce the number of unexpected interactions through its detailed analysis of the technology-in-society.

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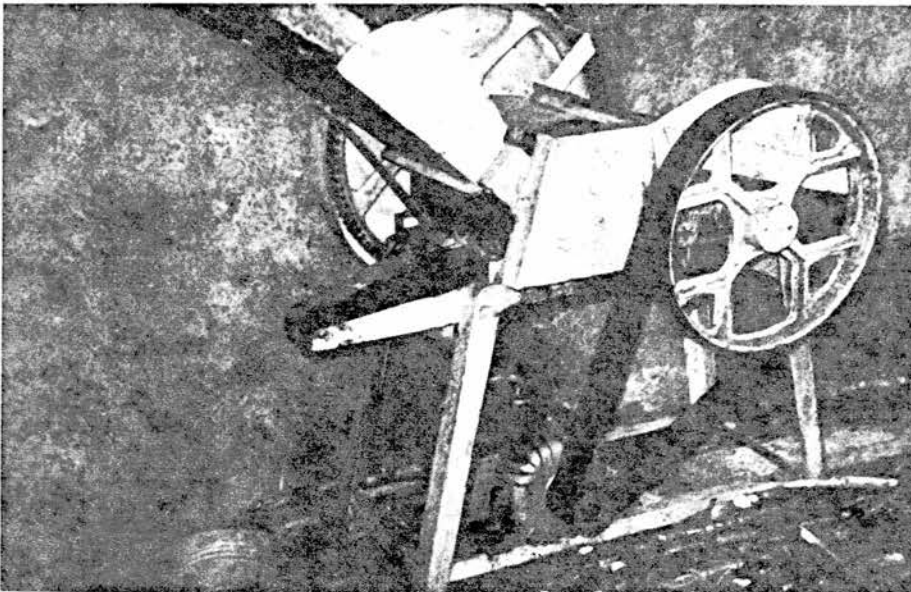
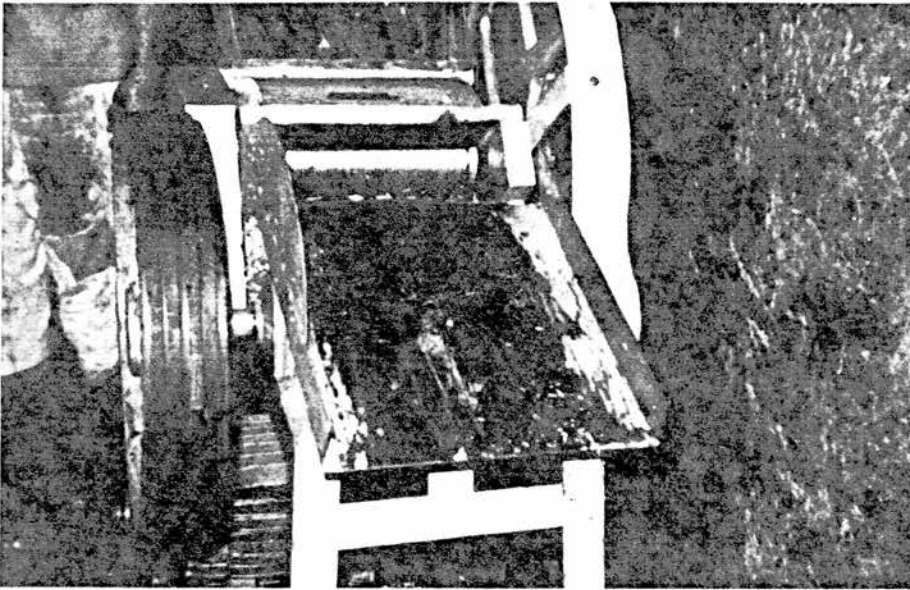
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† These requirements have been derived from the study of the dynamics of the introduction of sugarcane by-product utilization technologies. They are summarised here, in this way, as a guide to future action.

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APPENDIX 1

IPT Microdistillery - photographs



*Fotos 1 e 2*

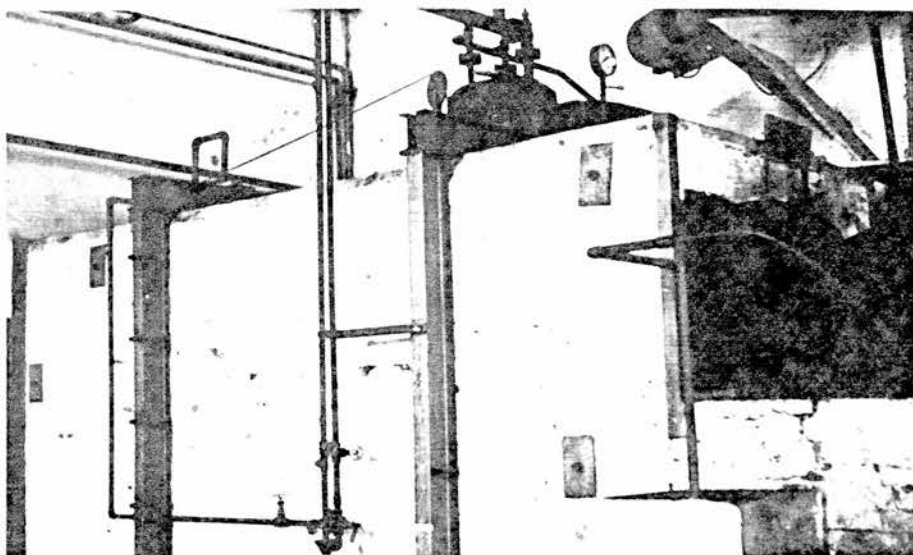
Moenda para extração de caldo



*Foto 5*

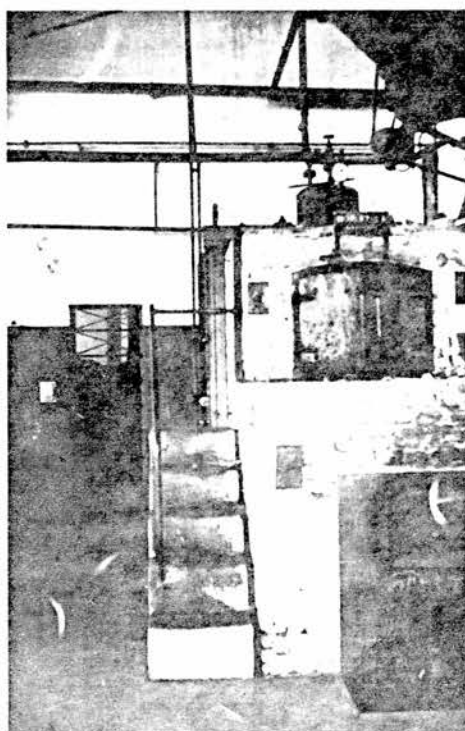
Caldeirão da coluna de destilação





↑ Foto 3

Caldeira e Fornalha



◆ Foto 4

Fornalha para geração de vapor



## APPENDIX 2

### Small scale Pulp Production in India

#### CHAPTER 5

##### PROCESSES ADOPTED IN SMALL MILLS

##### 5.1. PULPING

##### 5.1.1. Straw Pulp (Writings and Printings, bleached grade)

The straw is first chopped into small pieces, 35% to 50% long, by a mechanical chopper. Dusting is included with chopping or should follow it. The chopped and dusted straw is then taken by conveyer to the digester section for cooking. The digesters are normally of rotary spherical type, 12.5 ft. in diameter, with a capacity of 25 cubic metres and the numbers of digesters employed varies according to the output required. Caustic liquor in the ratio 4:1, liquor : straw is added with the caustic concentration such as to represent 8% to 12% on bone-dry straw. Occasionally cylindrical rotating digesters are used but the spherical type is more common, practically standard, in India. The steam pressure is between 6 to 8 atmospheres and the cycle as follows:-

Charging, straw and liquor	2 hours
Steaming (1 hr) and pressure cooking	3½ hours
Discharging	½ hour
Total Cycle	6 hours

The cooked pulp discharges to a blow tank where the pressure is released and it is then diluted and screened, usually over a vibrating, Johnson type screen with perforations around 3% dia. Rejects amount to about 3%. The stock is then washed and at this stage is known as brown stock. The washer is normally a single, vacuum, drum type unit and the wash liquor is sent to drain or, if a recovery plant is included, to evaporators. The washed pulp is then diluted and screened again through a rotary outward-flow or Cowan type screen, and cleaned through centrifugal cleaners before passing over a decker, or thickener, to storage at 3% to 5% in the chlorination tower.

Bleaching is the standard, 3 stage C.E.H. system (chlorine-caustic extraction and calcium hypochlorite). Chlorine around 3.5% of pulp is added in gaseous form upwards through the chlorination tower. A vacuum washer follows and the pulp then passes at 4% - 5% consistency to the extraction tower where caustic soda to the extent of 2% of pulp is added. The pulp is diluted and washed again in a vacuum washer before passing to the hypochlorite tower where 3-5% by weight of chlorine is added as calcium hypochlorite.

The pulp is now bleached and has brightness around 73°GE. It is then diluted and cleaned again through 2 or 3 stage centricleaners before passing over a thickener to storage for paper-mill use. The inherent ash, chiefly silica, can be as high as 10% and the freeness around 215 Canadian. Overall yield is 30% to 35%. Corresponding characteristics from bagasse would be, from the same process brightness, 80 - 85° GE, freeness, 450 to 500 Canadian, ash 1.0 - 1.7% and yield 40% - 45%, indicating its superiority as a raw material. The cooking time would be shorter but cooking chemical greater. The latter is not important if recovery is included. Bagasse, when available only in small quantity is sometimes added to the straw to improve the pulp quality.

The foregoing is illustrated in Figure 3 diagrammatically. There can be variations according to scale and quality. The blow tank is sometimes omitted and pulp emptied on to a drainage floor or directly to washer troughs. Vacuum washers may be replaced by simple breaker type drum washers. Single stage hypo-bleaching may be used where standards are lower, and only one stage of centricleaners. The flowsheet and description above, however, are typical of what would be installed for straw pulp manufacture in the new mills under construction. The variations mentioned above are representative more of the older operating mills of lower capacity, below 15 T.P.D.

#### 5.1.2. Bagasse Pulp (Writings and Printings)

Up to 30 T.P.D., the bagasse pulping system is virtually the same as described above for straw, except that de-pithing replaces the chopping and dusting preparation because pith in the sugar cane is undesirable. It does not contribute to the paper-making fibre but absorbs chemicals and reduces the pulp freeness so that the paper-making process is slower and drying more difficult. Bagasse requires more caustic for cooking, up to 27% on pulp produced but, the cooking time is shorter.

Above 30 T.P.D. bagasse pulping (and straw) is usually continuous because one continuous, screw-type digester is less expensive in capital cost and space requirements than a multiplicity of spherical digesters; it still further reduces cooking time, down to 12-15 minutes, and ensures more uniform pulp quality. The elementary system outlined above normally becomes more sophisticated, with increasing scale for operating cost reduction or qualitative reasons. Three stage, counterflow brown stock washing gives cleaner pulp, washes out more chemical for recovery and concentrates the extracted black liquor, reducing the evaporator burden for recovery. Heat exchangers are incorporated to provide hot washing water, more effective than cold water.

#### 5.1.3. Rag or Cotton Waste Pulp

The scale is usually smaller than for straw or bagasse because rag pulp is normally used as a long-fibre blend to impart strength and quality, seldom exceeding 20% of the total furnish, or, in higher proportion for hand made papers where total output is very small.

The cotton waste or rags are first cut to small pieces, using a rag-chopper, are dusted and then charged into a single spherical digester. It is customary today to sort mixed rags to eliminate synthetic material which will not pulp and this necessary function is presenting an ever-increasing problem. The chopped and dusted rags are cooked for around 3 hours in the digester with 4% of caustic soda using steam at 4 to 6 atmospheres pressure. The resultant pulp is then dumped into a drainage chest where the cooking liquor drains off.

#### 5.1.5. Other Processes Used in Small Mills

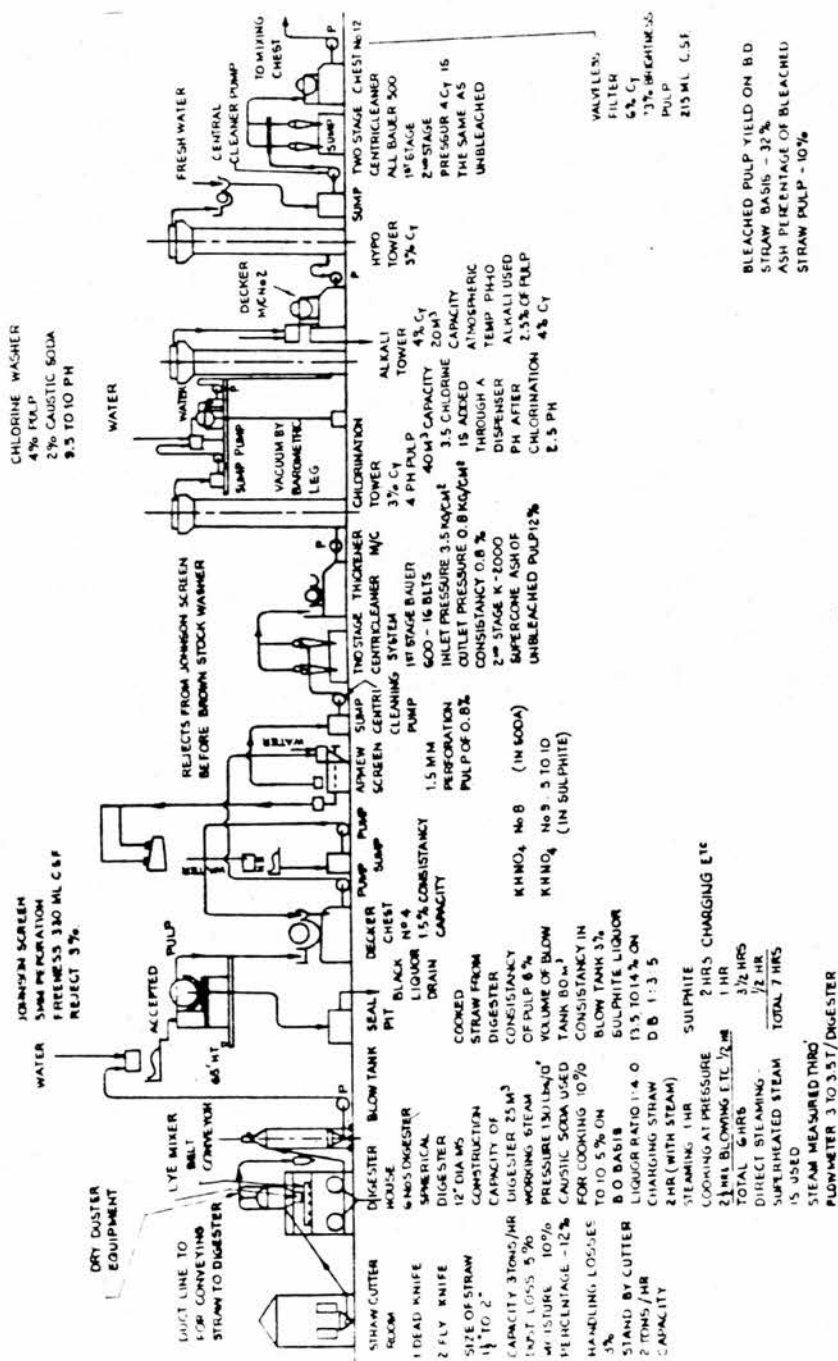
##### 5.1.5.1. Neutral Sulphite Semi-Chemical

This process uses sodium sulphite ( $\text{Na}_2\text{SO}_3$ ) and sodium carbonate ( $\text{Na}_2\text{CO}_3$ ) as the cooking chemicals but the same digester and washing plant are utilised. The cook is harder, the yield higher, bleaching more difficult and chemical-consuming so its use is confined mainly to pulp for packaging papers, particularly corrugating medium. Chemical recovery is not practical.

##### 5.1.5.2. Chemi-Mechanical (Mechano-Chemical) Process

This process has the merits of lower capital costs, higher yields and lower chemical consumption, at the expense of some quality but for many of the smaller mills around 10-15 T.P.D. the economies outweigh the quality considerations. For wrapping grades of paper the quality is not impaired to any significant degree, and may in fact be improved.

The chopped fibre is fed with water into open vessels, normally the Indian version of the Hydrapulper, and steam is injected to raise the temperature to  $100^\circ\text{C}$ , atmospheric boiling point. The pulp consistency is about 10% and the cooking time 30-60 minutes. From 5% to 10% of caustic is added. Bleaching can follow, single stage or 3-stage, as required and the overall yield is around 45% to 50%. The fibre is less well cooked and harder, but washes better on this account. More mechanical treatment subsequently is required than for fully-cooked pulps of similar materials, hence the name, but this is not serious for the small mill. Chemical recovery is not normally incorporated because the relatively small quantity of chemical used would not justify the plant required and the effluent burden can be tolerated. The system is shown diagrammatically in Figure 4A. In recent times more attention is being paid to this process by the larger mills because of the yield and other attractions. It can be adapted using batch or continuous digesters, and hot-stock refiners of large capacity, fulfil the mechanical requirements.



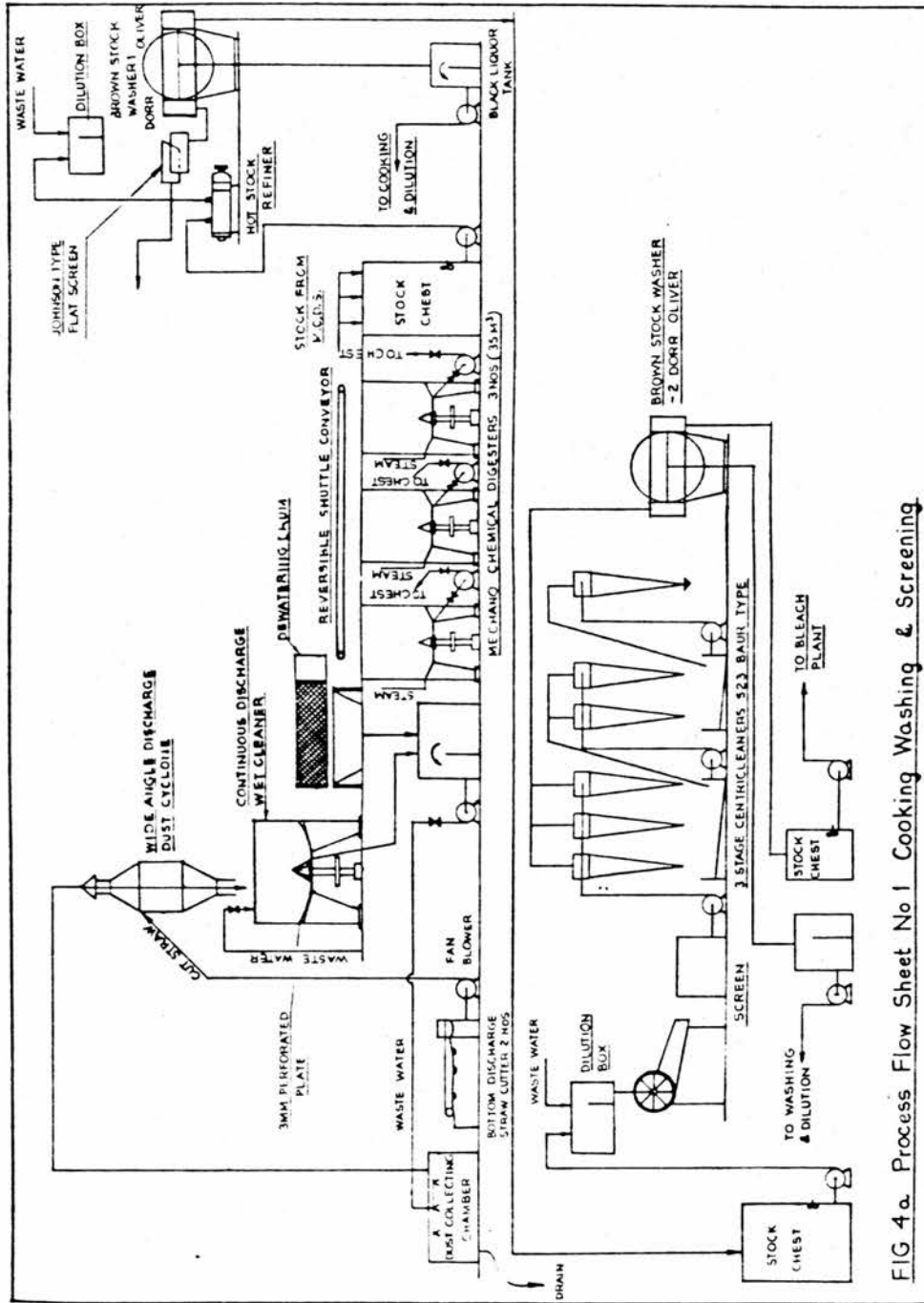


FIG 4a Process Flow Sheet No 1 Cooking Washing & Screening

### Appendix 3.

#### Financial data and calculations for the Universal Board Co.

#### case study.

##### 1. Production costs

Luc Lam(1) calculated the production cost of 19 mm board at this factory at full production capacity (15 t/d or 3750 t/a) and at one third capacity (125 days production, 1250 t/a). However, the company never managed to sell even 1250 t in one year. The sales of Top Board, broken down by the board thickness, are given in figure A3.1.

Figure A3.1 Annual sales of Top Board in tonnes.

Financial year	Normal sales:							Special Order
	4 mm	6 mm	13 mm	16 mm	19 mm	25 mm	30 mm	Total
1971/72								131
1972/73								319
1973/74								697
1974/75								779
1975/76								488
1-6/1976	26.48	47.35	111.7	4.14	83.29	0	16.55	289.51
1976/77	77.15	139.65	181.13	2.29	129.27	0	14.80	544.29
1977/78	43.33	66.18	135.93	47.52	98.89	0	9.40	401.25
1978/79	30.40	65.88	123.98	1.89	97.31	9.44	5.38	334.28
7-12/1979	11.32	5.49	59.06	5.00	29.79	3.56	9.85	124.07

Note: The special order was for the new Registry House in Port Louis, and was mostly special 49 mm particleboard.

Sources: Interview with M. Raffray(2), and information provided by his secretary(3).



The annual sales are presented in figure 3.1.

As figure A3.1 shows, not only were the total sales lower than the production capacity of the plant, but much of the board sold was thinner than the 19 mm standard in particleboard plant costings(1,4,5). This can be more clearly seen in figure A3.2, in which the sales of each thickness are presented as percentages of the total sales.

Figure A3.2 Sales breakdown by board thickness, excluding the special order.

Financial year	Board thickness:						
	4 mm	6 mm	13 mm	16 mm	19 mm	25 mm	30 mm
Jan.-June 1976	9.1%	16.4%	38.6%	1.4%	28.8%	0%	5.7%
1976/77	14.2%	25.7%	33.3%	0.4%	23.8%	0%	2.7%
1977/78	10.8%	16.5%	33.9%	11.8%	24.6%	0%	2.3%
1978/79	9.1%	19.7%	37.1%	0.6%	29.1%	2.8%	1.6%
July-Dec.1979	9.1%	4.4%	47.6%	4.0%	24%	2.9%	7.9%
1976-9	11.1%	19.2%	36.1%	3.6%	25.9%	0.8%	3.3%

Note: these are percentages of the total sales in each period. The special order was for the new Registry House in Port Louis, and was mostly special 49 mm particleboard.

The proportions of the different thicknesses sold appear to have remained constant over the years. To check on this a one-way analysis of variance was performed on this data. The result was a variance ratio of 47.28 for 6 degrees of freedom of the numerator and 28 degrees of freedom of the denominator, which result is highly significant ( $p < 0.1\%$ ). As the sales and thicknesses were so closely associated, the average sales breakdown (the last line in figure A3.2) is used in all further calculations.

The board thickness affects the production cost in several ways:

- i. less weight of thin board can be pressed per hour,
- ii. boards of different thicknesses have a differing proportion between the surface layers (fine particles, more glue and less hardener) and the core (coarse particles, less glue and more hardener),
- iii. and 1.2 mm is sanded off every board, regardless of thickness - this is a greater proportion wasted on thin boards.

The differences between boards of differing thickness are summarised in figure A3.3. Using these values, the quantities of raw materials needed to produce one tonne of board of each thickness can be calculated. This has been done for 19 mm board by Lam(1). A sample calculation from this is shown in figure A3.4. The quantities of raw materials required to produce one tonne of each of the other principal thicknesses of board have been calculated by the author, and are shown in figure A3.5, together with weighted averages based on the proportions sold in 1976-9.

Other inputs were related to the production time, notably the fuel needed to heat the press, the electricity used and labour costs. The average production rate when producing the mixture of thicknesses sold by this factory has been calculated, and is shown in figure A3.3. This is 660 kg board/hr, which is a 15% reduction in capacity compared to that achieved when producing only 19 mm particleboard. Because of this these time-related costs were higher than estimated by Lam. Applying this figure for the production rate to Lam's figures for hourly fuel oil, electricity and labour usage(1), the following

Figure A3.4 Sample calculations of raw materials requirements from Lam(1).

## APPENDIX I

## CALCULATION FOR PRODUCTION SPECIFICATIONS

## 1. Type of Board

Dimensions of finished Board =  $3.05 \times 1.22\text{m}$

Dimensions of untrimmed Board =  $3.10 \times 1.27\text{m}$

Specific weight =  $600\text{kg/m}^3$

Thickness of the finished board =  $19\text{mm}$

Thickness of the unsanded board =  $20.2\text{mm}$

2. Weight of trimmed Board =  $(3.05 \times 1.22 \times 0.0202) \times 600 = 45.10\text{kg}$

3. Weight of sanded Board =  $(3.05 \times 1.22 \times 0.0190) \times 600 = 42.42\text{kg}$

4. Weight of untrimmed Board =  $(3.10 \times 1.27 \times 0.0202) \times 600 = 47.72\text{kg}$

## 5. Dry weight of untrimmed Board

Approximate moisture content of Board (outlet of press) is  $9\%$

Dry Weight of untrimmed Board =  $\frac{47.72 \times 100}{109} = 43.80\text{kg}$

## 6. Repartition of the different layers

Surface layer :  $40\%$  on the dry weight of the untrimmed board.

$\frac{40}{100} \times 43.80 = 17.52\text{kg}$

At a moisture content of  $17\% = \frac{17.52 \times 117}{100} = 20.50\text{kg}$

Core layer :  $60\%$  on the dry weight of the untrimmed board

$\frac{60}{100} \times 43.80 = 26.28\text{kg}$

At a moisture content of  $11\% = 26.28 \times \frac{111}{100} = 29.17\text{kg}$

## 7. Quantity of glue and dry bagasse particles per board

Surface layer: dry weight =  $17.52 \text{ [kg]}$

Surface layer: Solid glue on dry surface particles =  $10.5\%$

Dry bagasse =  $17.52 \times \frac{100}{110.5} = 15.86 \text{ [kg]}$

Solid glue =  $\frac{10.5}{100} \times 15.86 = 1.665 \text{ [kg]}$

Dry weight =  $26.28 \text{ [kg]}$

Solid glue on dry core particles =  $8.6\%$

Dry Bagasse =  $26.28 \times \frac{100}{108.6} = 24.20 \text{ [kg]}$

Solid Glue =  $24.20 \times \frac{8.6}{100} = 2.081 \text{ [kg]}$

## 8. Quantity of prepared glue per board

Surface layer =  $1.665 \times 2.52 = 4.20 \text{ [kg]}$

Core layer =  $2.081 \times 1.88 = 3.91 \text{ [kg]}$

## 9. Pressing cycle

Total pressing cycle for =  $6 \text{ } 1/2 \text{ [min]}$

## 10. Quantity of dry bagasse particles (bone dry)

Surface Layer:

Dry bagasse chips per board =  $15.86 \text{ [kg]}$

Dry bagasse at  $3\%$  humidity per board =  $(5.0)$

Dry bagasse chips per press =  $15.86 \times 2 = 31.72\text{kg}$

Dry bagasse chips per minute =  $31.72 \div 6.5 = 4.88 \text{ [kg/min]}$

Dry bagasse chips per hour =  $4.88 \times 60 = 293\text{kg}$

Core layer:

Dry bagasse chips per board =  $24.20 \text{ [kg]}$

Dry bagasse at  $3\%$  humidity per board =  $(5.0)$

Dry bagasse chips per press =  $48.40 \text{ [kg]}$

Dry bagasse chips per minute =  $48.40 \div 6.5 = 7.45\text{kg}$

Dry bagasse chips per hour =  $446\text{kg}$

Figure A3.3 Characteristics of boards of different thicknesses.

Thickness/mm	4	6	13	16	19	30	Average
% surface	100	100	40	40	40	33*	
Unsanded thickness/mm	5.2	7.2	14.2	17.2	20.2	31.2	
Density/kg m <sup>-3</sup>	750	675	600	600	600	450	
Areal dens./kg m <sup>-2</sup>	3.00	4.05	7.80	9.60	11.40	18.00	
Sp. surface/m <sup>2</sup> t <sup>-1</sup>	333	247	128	104	88	56	159
Wt. of board/kg	11.2	15.0	29.0	35.7	42.4	50.2	23.2
Pressing cycle/min	2.5	3.5	4.5	5.5	6.5	10.0	
Boards per hour	48	34	26	22	18	12	
Prodn. capacity/(kg/hr)	537.6	510.0	754.0	785.4	763.2	602.4	660.1

\* Estimated from the density

Source for the densities, pressing cycles, and the proportion of surface to core layers: Raffray(2)

The board weight was calculated from the thickness, density and the standard finished board length and width (3.05 m x 1.22 m(1) ). Hence the production capacity.

The average is weighted according to the quantities of each thickness sold in 1976-9.

Figure A3.5 Raw materials required to produce 1 t of board.

Raw materials kg	Board thickness/mm						Aver.
	4	6	13	16	19	30	
Dry bagasse	1248	1152	1060	1043	1031	1010	1088
Dry resin	133	122	99.2	97.7	96.6	92.8	106.3
Paraffin wax	5.96	5.50	4.47	4.40	4.35	4.20	4.79
Emulsifier	0.65	0.60	0.49	0.48	0.47	0.46	0.52
Ammonia	0.12	0.11	0.09	0.09	0.09	0.08	0.10
NH <sub>4</sub> Cl	2.68	2.47	3.10	3.05	3.02	3.04	2.91
Urea	6.63	6.12	4.96	4.88	4.83	4.76	5.32
Xyligen 30F	17.0	15.7	14.3	14.1	13.9	13.6	14.7
Process water	220	203	127	125	124	115	151

The averages are weighted according to the 1976-9 sales.

are obtained:

Fuel oil for press = 17.5 kg/hr = 26.5 kg/t board

Electricity                = 472 kW                = 715 kW hr/t board

Labour: skilled           = 8 men/shift           = 12.1 man hr/t board

semi-skilled             = 11 men/shift           = 16.7 man hr/t board

Other fuel oil is used for drying bagasse. Lam calculates the usage assuming all the heat of combustion of the oil is used to evaporate water from the bagasse. On this basis he calculated a fuel oil consumption for drying bagasse of 62.7 kg/hr, which was reduced to 24.3 kg/hr with mixed fuel oil and bagasse dust firing. This was to dry 808 kg/hr dry weight of bagasse(1). As the factory always produced well below capacity, it rarely ran on three shifts, so more fuel oil had to be used as no bagasse dust could be fired until the furnace temperature reached 600 °C(1) - say for 45 min in a double shift of 14 hr 40 min (22 hr x 2/3), or 5% of the operating time. Assuming this, the average fuel oil consumption for drying bagasse would have been 26.2 kg/hr = 32.5 kg/t bagasse = 35.3 kg/t board (at 1.088 t bagasse/t board; see figure A3.3).

Hence the total fuel oil consumption = 61.8 kg/t board.

Sanding costs depended on the number of boards produced. For 19 mm board this was 23.6 boards/t(1). For the mix as sold this came to 42.1 boards/t.

A further variable production cost was that of handling baled bagasse. According to Raffray(6) and Lam(1) in the first years of operation the factory was operated at the same time as the St. Antoine sugar factory, and took its bagasse directly from the sugar factory. From 1975/76 on the particleboard factory had to use a large

proportion of baled bagasse purchased from other factories, as St. Antoine was burning more bagasse, leaving a greatly reduced surplus. This was claimed to be due to the cyclone Gervaise in 1975 and cane harvesting difficulties in the subsequent years leading to more frequent factory shutdowns, needing bagasse to restart the boilers more often(6). It should be pointed out, however, that the total number of crushing hours per day for St. Antoine before and after 1975 were much the same, i.e. 20.72, 21.00, 19.41, 15.91, 19.94, 19.13, and 19.94 hr for 1972 to 1978 respectively(7).

Assuming that from 1975/76 onwards 80% of the bagasse was purchased in bales. This had to be stacked, unstacked, and fed to the factory, requiring 2.1, 8 and 6.4 man hr/t dry bagasse respectively of semi-skilled labour. In all this came to 15.5 man hr/t baled bagasse or 13.2 man hr/t total bagasse.

∴ labour for unbaling = 14.4 man hr/t board.

Total labour: skilled = 12.1 man hr/t board.

semi-skilled = 31.1 man hr/t board.

Given these physical relationships and the unit costs of the different inputs, the variable production cost can be calculated. This has been done for four different periods: 1974 (when Lam wrote his report(1) ), 1975/76, 1976/77 and 1979. The unit costs of the inputs, and the quantities required to produce one tonne of particle board (at the average mix of thicknesses) are shown in figure A3.6. Figure 3.14 shows the relative importance of the different inputs in the variable cost, and figure A3.7 compares the total costs with the actual production costs from the accounts for several financial

years.

Figure A3.6 Inputs per tonne board produced, and unit costs.

Input	Quantity/t board		Unit costs (Rs) in:				% increase over 5 years
	Ledune	UBC	1974	1975/76	1976/77	1979	
<u>Raw materials</u>							
Bagasse/t	-	1.088	0	43.00	43.00	70.00	(if
Chemicals/kg:							
Resin	87.00	106.3	3.10	3.04	3.50	4.04	30
Paraffin wax	5.00	4.79	2.50	2.50	2.62	3.68	47
Emulsifier		0.52	15.00	17.90	17.60	18.44	23
Ammonia	1.54	0.10	3.50	3.50	3.50	3.50	0
NH <sub>4</sub> Cl	2.00	2.91	1.85	2.13	2.75	3.57	93
Urea	0	5.32	0.85	2.00	2.50	1.75	106
Fungicide	0	14.7	11.00	12.57	13.85	16.65	51
Sandpaper							
cost/board	?	43.1	0.35	0.43	0.48	0.54	54
Fuel oil/kg	37	61.8	0.67	0.83	0.92*	1.92 <sup>†</sup>	187
Elect./kWh	480	715	0.195	0.217	0.26	0.42	115
<u>Labour/man hr</u>							
Skilled	23.2	12.1	2.50	3.00	3.73	4.69	87
Semi-skilled	10.4	31.1	1.875	2.25	2.80	3.51	87
Unskilled	49.5	0	-	-	-	-	-

Sources:

Electricity cost from the CEB Annual Reports(8,9,10,11,12).

Labour costs from Lam(1) for 1974 and increased according to the index of wages of sugar factory workers in Leung Shing(13).

Fuel oil costs assume a specific gravity of 0.87 except for that for 1974 which was given on a weight basis. <sup>†</sup> - from the CEB Annual Report for 1979, the basis of the fuel cost electricity price adjustment clause(12). \* - Lam's price inflated at the same rate as the increase in diesel prices according to Dinan(14).

All other prices were taken from Lam(1) (for 1974), Raffray(2) (for 1975-77), and a list provided by Raffray's secretary in 1980(3) (for 1979).

The quantities required per tonne board are for the Universal Board Co. (UBC) as calculated above, and for a proposed 12 t/d wood-based plant in a case study for FAO(5).

Comparing the results of applying Lam's production cost model to the actual mixture of thicknesses sold in several years of operation and the production costings used for the cost of sales calculations in the company's accounts(15), it can be seen that the raw materials



Figure A3.7 Comparison of predicted and actual production costs.

Rs/t board	Raw material		Fuel oil		Electricity		Labour	Man. fee
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1973/74		426		86		194		91
1974	536		41		181		89	
1974/75		376		85		132		196
1975/76	612	638	51	102	155	210	106	321
1976/77	686	653	57	127	186	338	132	769
1977/78		1144		193		344		385
1979	821		119		300		166	

(1) Calculated from figure A3.6.

(2) From the Universal Board Company accounts.

The electricity costs under (1) are only for the kWh used. Those under (2) include the maximum demand charge as well.

The management fee included labour, factory management, water, lubricating oil and grease, insurance of bagasse and transport.

costs are similar. Differences arise from small differences in the thicknesses of the boards sold and the fact that the stocks of raw materials fluctuated, so in some years board was made from old, cheaper, stocks of raw material. The prices used here in the calculations (in figure A3.6) were current during the indicated years, therefore, the calculations assume that all production was from new stock. The differences in fuel oil costs can be attributed to the shorter working periods of the particleboard factory, which limited the extent of bagasse dust burning, and to Lam's assumption of perfect heat transfer and zero losses in his calculation of the fuel oil requirements for drying. On the other hand he assumed that the factory electricity consumption was continuously 80% of the rated capacity (in kVA), which resulted in an overestimate of the direct electricity cost. There should have been a greater difference between the two columns for electricity cost, as that derived from the accounts includes the high maximum demand charge which had to be paid whether

or not the factory was operating. It appears that the management fee only covered the cost of labour in 1973/74, but rose in 1974/75 to cover the labour cost plus supervision (Rs60 k for production of 3750 t/a or Rs 80k for production of 1250 t/a according to Lam(1) ), plus the bagasse insurance cost (estimated as the difference between Lam's figure of Rs45 k and the figure for insurance paid directly by the Universal Board Company of Rs17 k(15) ). Afterwards the management fee increased to an approximately constant annual charge, suggesting that the wages were charged to the particleboard factory whether or not it was in production, although the workers and factory management were employed in the sugar factory when the particleboard plant was not operating.

## 2. Selling prices

Figure A3.8 gives the selling prices of the different thicknesses of "Top Board" from 1973 to 1978. The average selling price per square metre has been calculated for the mixture of board thicknesses sold so that these can be compared with the average plywood import prices (see figure 3.21).

## 3. Sensitivity analysis calculations.

These are based on the accounts for 1978(15) and on the relationships already calculated in figures A3.1, A3.6, 3.14, 3.16 and 3.26. The results are given in figure 3.27. From figure A3.1 we have:

$$\text{Sales in 1973/74} = 697 \text{ t, and in 1977/78} = 745.21 \text{ t} \quad (1)$$

From figure A3.6:

$$\text{Electricity use} = 715 \text{ kWh/t board} \quad (2)$$

Figure A3.8 Factory selling prices of "Top Board" 1973-78

Date of increase	Prices in Rs/m <sup>2</sup> for "Top Board" of:						Aver.
	4 mm	6 mm	13 mm	16 mm	19 mm	30 mm	
July '73	4.20	6.60	11.60	12.70	14.50	20.90	8.96
Mar. '74	4.60	7.20	12.80	14.00	16.00	23.00	9.86
July '74	5.20	7.90	14.10	15.30	17.50	25.20	10.86
Mar. '75	5.50	8.48	15.40	16.80	21.20	27.70	12.07
Oct. '76	6.20	9.50	17.20	20.30	23.70	31.00	13.55
Jan. '77	6.20	10.30	18.90	22.30	26.00	34.00	14.69
July '77	6.50	11.30	20.80	24.40	28.60	37.40	16.08
Jan. '78	6.50	12.40	22.80	26.90	31.40	41.10	17.50
June '78	7.10	12.90	23.90	29.60	34.40	43.00	18.62
Proportion of sales/%	23.2	29.7	29.0	2.4	14.2	1.4	100

Calculated from selling prices in Rs/ft<sup>2</sup> provided by Raffray in 1977 and 1980(2,3).

Selling prices at the wholesalers were the above plus 18.5%.

The averages are weighted according to the areal proportions of the different thicknesses sold, as calculated in figure A3.3.

From figure 3.14:

$$\frac{\text{Bagasse}}{\text{Raw materials}} = \frac{5.4}{59.1} \quad (3)$$

$$\frac{\text{Fungicide}}{\text{Raw materials}} = \frac{17.4}{59.1} \quad (4)$$

From figure 3.16:

$$\frac{\text{Raw materials}}{\text{Variable costs}} = \frac{215.2}{418.1 - 9.0 - 72.4} = \frac{215.2}{336.7} \quad (5)$$

$$\frac{\text{Electricity}}{\text{Variable costs}} = \frac{64.8}{336.7} \quad (6)$$

$$\frac{\text{Management fee}}{\text{Fixed costs}} = \frac{72.4}{81.4} \quad (7)$$

$$\frac{1973/74 \text{ Prod. cost(excl. depn.)}}{1977/78 \text{ Prod. cost(excl. depn.)}} = \frac{100.0}{418.1} \quad (8)$$

From figure 3.26:

$$1977/78 \text{ rent} = \text{Rs } 48 \text{ k} \quad (9)$$

From these relationships were calculated the profits under different conditions. For example, the cost of fungicide was calculated

thus:

$$\begin{aligned}\text{Fungicide} &= (4) \times (5) \times (\text{Variable costs}) \\ &= \frac{17.4}{59.1} \times \frac{215.2}{336.7} \times \text{Rs } 1376 \text{ k} = \text{Rs } 259 \text{ k}\end{aligned}$$

$$\therefore \text{Variable cost (B)} = \text{Rs } 1117$$

The variable cost when the bagasse is free was calculated in an identical manner.

For the cost with electricity at Rs0.04/kWh, the variable cost excluding electricity was calculated as above, and then the electricity cost was estimated as follows:

$$\begin{aligned}\text{Electricity cost} &= 715 \text{ kWh/t} \times 745.21 \text{ t} \times \text{Rs } 0.04/\text{t} \\ &= \text{Rs } 21 \text{ k}\end{aligned}$$

The fixed and variable production costs at 1973/74 prices were calculated as follows:

$$\begin{aligned}\text{Fixed + variable production cost} &= (8) \times (\text{Fixed + variable cost}) \\ &= \frac{100}{418.4} \times (\text{Rs } 361 \text{ k} + \text{Rs } 1376 \text{ k}) \\ &= \text{Rs } 415 \text{ k}\end{aligned}$$

The income at 1973/74 selling prices was calculated from the sales income in the accounts for 1973/74 and 1977/78, and the quantities sold in these years, thus:

$$\text{Sales income at 1973/74 prices} = \frac{\text{Rs } 1227 \text{ k}}{697 \text{ t}} \times 745.21 \text{ t} = \text{Rs } 1312 \text{ k}$$

The rent was taken from (9), halved and subtracted from the administration costs, and the management fee was calculated as follows:

$$\begin{aligned}\frac{1}{2} \times \text{Management fee} &= (7) \times (\text{Fixed costs}) \\ &= \frac{1}{2} \times \frac{72.4}{81.4} \times \text{Rs } 361 \text{ k} = \text{Rs } 161 \text{ k}\end{aligned}$$

The calculation of the effect of an increase in the unit selling price is self evident. The effects of changing the sales volume is less so. For these, the sales income and variable production costs are either doubled or halved, while the other costs remain constant, except for the selling costs. It is assumed that either a salesman is employed all year round to increase the sales or no advertising is done and the sales volume is allowed to fall; hence the selling costs.

The currency loss on the DM loan affected the profitability in two ways. It increased the debt burden by Rs0.9 M, and the fixed assets were revalued to take account of this. So, both the depreciation and interest payments were higher. The savings if no such foreign loan had been taken were calculated assuming a 10% interest rate (the same as the later special loans, see figure 3.23) and the depreciation rate at 8.7% of the machinery and equipment.

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# APPENDIX 4

## Cost-benefit analysis of Indian mini-mill paper technology applied to Mauritian conditions.

This follows the methodology of Little and Mirrlees(1), as used by Scott in his report "Estimates of accounting prices for Mauritius"(2). The accounting ratios used were taken from Scott's report and appendix IV. Some of these were recalculated on a c.i.f. price basis, rather than the Mauritian purchase price basis used by Scott so that import prices in the Customs and Excise report(3) could be used. The ratios used are summarised in figure A4.1.

Figure A4.1 Accounting ratios for goods and services used in paper production.

Item	A	B
Commercial vehicles	0.764	0.899
Gas/diesel oil	0.759	0.859
Machinery & equipment:		
Industrial & Agricultural	0.892	1.048
Ditto (c.i.f. basis)	1.141	1.341
Office etc.	0.763	0.894
Misc. building materials	0.838	0.985
Unweighted average of tradables	0.809	0.950
Ditto (c.i.f. basis)	1.149	1.349
Buildings	0.818	0.929
Industrial electricity	1.704	1.995
Misc. office services	0.703	0.742
Foreign exchange	1.0	1.2
Taxes etc.	0	0
"Surplus" men	0.4	0.4
"Surplus" women	0.5	0.5
Skilled labour	0.8	0.8
Misc. costs	0.8	0.8

Notes - A are accounting ratios according to Scott(2).

B are changed to allow for an assumed 20% overvaluation of the Mauritian rupee in 1977.

As Scott's paper was written in 1972, the accounting ratios may



well have changed by 1977, which is the date used for these calculations. In particular, the shadow wage rates may have changed, and the assumption that the exchange rate of the Mauritian rupee reflected the true value of foreign exchange may no longer have been valid in 1977. The unemployment rate, as far as it can be estimated, decreased from 1972 to 1974, accompanying the sugar boom, and then started to increase again. An idea of the changes in unemployment can be obtained by adding together the numbers of relief workers and Development Works Corporation employees. One source gives figures of 19.0, 16.8 and 17.6 thousands for the years 1972, 1974 and 1975 respectively(4). From the Bank of Mauritius report(5) and the Mauritius Economic Reviews(6,7) it is possible to calculate totals of 18.9, 16.5 and 17.3 thousands for the same years.

As a lower but increasing level of unemployment can be as serious as the high rate of unemployment in 1972, the accounting ratios for "surplus" labour have been left as calculated by Scott.

However, in view of the two devaluations of the Mauritian rupee in 1979 and 1981, it would be a brave man who asserted that the 1977 exchange rate reflected the true value of foreign currency to Mauritius. The increases in the balance of payments current account start before 1977, not just in 1979. This is shown in figure A4.2.

Figure A4.2 Mauritius. Balance of payments - current account (goods, services and transfers)

(Rs x 10 <sup>6</sup> )	1973	1974	1975	1976	1977	1978
Credit	2	311	127	-	-	-
Deficit	-	-	-	243	512	735

Source: Bank of Mauritius Report for 1979, p.91(5)

To take account of this, column B has been calculated in figure A4.1, assuming a shadow exchange rate such that the accounting ratio for foreign currency is 1.2 instead of 1.0 (equivalent to dividing all local inputs by 1.2). Both sets of accounting ratios are used in the cost-benefit analysis, so that the effects of any undervaluation of foreign currency can be identified.

These ratios were applied to 1977 Mauritian prices (where available) so that they can be compared with the Indian and Jamaican studies. figure A4.3 shows the Mauritian prices used in these calculations, and their sources. When no Mauritian prices were easily available to the writer, the Indian prices were used, converted at the 1977 exchange rate of Indian Rs 1 = Mauritian Rs 0.768(8). Machinery specially for papermaking was assumed imported into Mauritius from India including a 20% margin to cover freight costs.

The shadow prices have then been calculated by multiplying these prices by the accounting ratios given in figure A4.1. For example, for bagasse,

Shadow price = (labour cost x ratio for "surplus" men) + (binding cost x ratio for miscellaneous building materials) ; i.e.

Shadow price A =  $(30 \times 0.4) + (20 \times 0.838) = 28.8$  Rs/t, and

Shadow price B =  $(30 \times 0.4) + (20 \times 0.985) = 31.7$  Rs/t.

Applying these prices to the figures given in Western for a 15 t/d mill(15), except for the chemical usages which were taken from Rao(16), the following shadow costs and benefits are obtained. Figure A4.4 shows the capital costs, figure A4.5 the production costs, and figure A4.6 the revenues obtained.†

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† All figures in this section also give an estimate of the

Figure A4.3 1977 Mauritian prices.

Item	Cost/Rs		Note	S.I.T.C.
	c.i.f.	local		
Buildings/ft <sup>2</sup> (/m <sup>2</sup> )		39.06 3.629)	1	
Waste paper/kg	1.208	1.716	2	251.11
Cotton waste/kg	3.141	4.462	2	263.30
Other textile wastes/kg	2.010	2.856	2	265.80
Bagasse/t, (labour (binding		50 30) 20)	3	
Chemicals/kg:				
Sodium hydroxide	1.680	2.386	2	513.62
Chlorine	5.740	8.153	2	513.21
Alum	2.966	4.213	4	
Resins	8.45	12.00	2	292.20
Clay	1.618	2.298	2,5	276.21
Dyes	13.633	19.365	2	532.10
Metallic oxides	7.081	10.058	2	513.50
Laundry blue	7.954	11.298	2	531.01(10)
Prepared mordants etc.	12.946	18.389	2	599.74
Services:				
Electricity/kWh		0.35	6	
Steam/t:				
Oil-fired boiler		50	7	
Sugar factory		4	7	
Wages:				
Daily paid/day		16.17	8	
Monthly paid/month		1225	8	
Paper/kg:				
Printing & writing	5.842	8.298	2	641.21
Packaging - kraft	4.345	6.172	2	641.32
- other	3.643	5.175	2	641.52
Corrugated	5.205	7.393	2	641.93(20)
Newsprint	3.520	5.000	2	641.10

1. Cost of Plaine Lauzun Estate construction, from DBM report 1976, p.6(8) 2. C.i.f. import prices 1977 from Customs and Excise report for the S.I.T.C. quoted(3). Local prices by dividing by 0.704 (ratio of direct import cost to local price, average for non-consumer goods from Scott(2)). 3. Cost at Universal Board Co(9). 4. Clay price x Indian ratio of alum to clay prices. 5. Average price of imports from UK (presumably containing a large proportion of china clay). 6. CEB Report 1977(10) 7. Cost at Yeast Producers (Mtius) Ltd(11). 8. Average wages for the paper products industry in September 1978(12), deflated to 1977 by the cost of living index(13), plus 30% fringe benefits.

financial cost to a private entrepreneur. This will be discussed in the second addendum to this appendix.

Figure A4.4 Capital cost of a 15 t/d pulp/paper mini mill in Mauritius at 1977 shadow prices.

(kRs)	A	B	Fin.
Buildings	1692	1922	2069
Plant & equipment*	16267	19119	19035
Spares (2% of above)	325	382	381
Vehicles*	59	69	77
Office equipment etc.*	146	172	192
Pre-operation costs#	694	775	781
Sundries*	702	741	998
	19886	23180	23532
Contingencies (5%) and technical fees (2%)	1392	1623	1647
Total capital cost	21278	24802	25179

A - using accounting ratios from column A in figure A4.1.

B - using accounting ratios from column B in figure A4.1

\* - from Indian prices calculated as explained above.

# - from Indian prices, but calculated using the ratios of Mauritian shadow unit production costs to the Indian unit production cost.

In the production costing there are alternative values for the steam cost. One assumes that all the steam is generated in an oil-fired package boiler, the other that a third of the steam comes from a neighbouring sugar factory which can spare 135 t/d of steam. There are also alternative costs for fibrous raw materials, assuming that of the 200 kg rags/cotton waste/linters specified by Rao(16) 20 kg can be found locally as wastes of the Mauritian textile and clothing industries (see the addendum to this appendix). The rest would have to be imported, perhaps as long-fibre pulp or as textile wastes. Because of these alternative costs, there are upper and lower estimates (1 and 2 respectively) of the production cost under each set of accounting ratios (A and B).

The paper is assumed to be sold as non-kraft packaging paper, as



Figure A4.5 Unit production costs for a 15 t/d mini mill at 1977 Mauritian shadow costs.

Item	Quantity	Cost/(Rs/t paper)			
		A	B	Financial	
<u>Fixed costs:</u>					
Labour - unskilled	265 )				
- admin.	50	271	271	496	
Maint., consumables,)					
packing & dispatch	IRs 335	208	244	258	
<u>Chemicals:</u>					
Sodium hydroxide	250 kg	483	567	596	
Alum	60 kg	204	240	253	
Rosin	15 kg	146	171	180	
Clay	100 kg	186	218	230	
Dyes	IRs 40	35	41	31	
<u>Fibrous raw materials:</u>					
Bagasse	4.8 t	138	152	240	
Waste paper	120 kg	167	196	206	
Cotton waste, local	20 kg	1	1	1	
Imported pulp*	200 kg	520	611	643	
or imp. textile wastes	180 kg	416	488	514	
<u>Services:</u>					
Steam - oil-fired or	9 t	342	387	450	
- 1/3 from sugar mill	9 t	239	271	312	
Electricity	1.3 MWh	780	910	455	
Total production cost		3481	3273	4009	
		3273	3770	4038	
				3771	

A - using accounting ratios from column A in figure A4.1.

B - using accounting ratios from column B in figure A4.1

\* - pulp at 10% water, costing US\$ 360/t (the price paid by Pondicherry Papers Ltd. for unbleached sulphite pulp(15) ).

produced by the 15 t/d mill described in Western(15). The unit net revenues are then calculated, by taking away the different production costs, and then multiplied by the actual production of Western's typical 15 t/d plant (70% of capacity) to obtain the annual net cash flow.

From the annual revenues and the capital costs have been calculated the net present values (NPV) of the cash flow, discounted over 13 years of operation plus one of construction, at various discount

Figure A4.6 Unit revenues from paper sales at 1977 Mauritian shadow prices, for a 15 t/d mini-mill.

Accounting ratios -	A		B		Financial	
Production cost -	1	2	1	2	1	2
Selling price/Rs/t	4186	4186	4914	4914	5175	5175
Prod. cost/Rs/t	3481	3273	4009	3770	4038	3771
Net revenue/Rs/t	705	913	905	1145	1137	1404
Annual revenues at 4075 t/a /kRs	2873	3721	3689	4664	4632	5721

A - using accounting ratios from column A in figure A4.1.

B - using accounting ratios from column B in figure A4.1

1 - using steam from an oil-fired boiler and imported textile wastes.

2 - 1/3 of the steam from a sugar factory and using imported pulp.

rates and the internal rate of return (IRR), i.e. that discount rate which produces a NPV of zero. This has been summarised in figure A4.7.

Figure A4.7 Discounted cash flow analysis for a 15 t/d mini paper plant at 1977 Mauritian shadow prices.

Accounting ratios -	A		B		Financial	
Production cost -	1	2	1	2	1	2
Cash flows - year 0	-21.3	-21.3	-24.8	-24.8	-25.2	-25.2
- years 1-13	2.9	3.7	3.7	4.7	4.6	5.7
NPV at i=5%	5.4	13.0	9.4	18.1	18.3	28.7
7%	2.6	9.2	5.6	13.3	13.5	22.7
11%	-1.7	3.5	0.1	6.0	6.2	13.5
IRR	9%	14%	11%	16%	16%	21%

All cash flows and NPVs in millions of Rupees.

A similar calculation was made for a much smaller handmade paper plant, based on a costing provided by Coromandal Hydraulics(17). This was a project report produced by an Indian equipment supplier to the handmade paper industry, who used a cylinder mould vat rather

than a hand lifted frame. This hand operated mould is similar in concept to the machine driven moulds used in some paperboard plants. They quoted accurate capital cost figures (as they were selling), and calculated the returns for certain paper products: pulp board, white card, grey card sheets and grey boards.

As their calculations do not envisage the use of bagasse, certain modifications had to be made to arrive at an approximate costing of such a plant based on bagasse. The raw material usage was taken from Rao's paper(16) but with additional chemicals, as specified in Coromandal Hydraulics' project study(17), needed to produce higher quality paper. To the capital cost in the report was added the cost of mini-digesters for the bagasse. Bagasse was also substituted for firewood as a fuel for heating the digesters. The 24 t/a of cotton waste needed should be available in Mauritius.

Since such a small mill would only be considered in Mauritius for the production of premium grades of paper, and not be expected to compete with Packaging Industries Ltd. for the packaging paper market, the calculation has been based on the production of white card, at 400 kg/d in two shifts.

Otherwise the same assumptions were made as in the previous cost-benefit calculation. The results are shown in figure A4.8 (capital cost), figure A4.9 (production cost), figure A4.10 (revenue) and figure A4.11 (cash flow analysis).

The production cost figures are somewhat less certain than in the previous study, as the quantities of bagasse and chemicals needed to digest the bagasse are taken from a study of a 15 t/d plant, whereas a 400 kg/d to 1 t/d plant might require different quantities.



Figure A4.8 Capital cost of 400 kg/d handmade paper project at 1977 Mauritian shadow prices.

Item	Quantity	Cost/kRs		
		A	B	Fin.
Buildings	654 m <sup>2</sup>	225	256	275
Pulp and paper machinery		154	181	180
(project report	IRs 138600 )			
(+ 2 mini digesters	IRs 7800*)			
(+ freight	20%)			
Electric motors, starters )	IRs 42800	29	34	33
and other industrial equip.				
Office equipment	IRs 4000	2	3	3
Erection	IRs 40000	25	25	43
Total		435	498	534

A - accounting ratios from column A in figure A4.1

B - accounting ratios from column B in figure A4.1

\* - From an invoice sent to the writer by Coromandal Hydraulics(18).

Furthermore, little handmade paper is made in India from bagasse, as they have had difficulties producing high quality writing paper at this scale. Here it is assumed that bagasse pulping at this scale is not too different from its pulping in 15 t/d(16) or 10 t/d(15) mills.

As bagasse has rarely been used to produce high quality printing and writing papers in handmade plants, although often used for this in mini-mills of 15 t/d capacity, the sales have been calculated both as sales of printing and writing paper and alternatively as sales of packaging paper, in case the plant cannot at first produce printing and writing paper.

#### 1. Addendum - Cotton waste availability in Mauritius.

This was calculated from the 1977 import statistics for cotton fibres, yarn and thread, and woven fabrics(3), as shown in figure A4.12.

Figure A4.9 Production costs for a 400 kg/d handmade paper plant at 1977 Mauritian shadow prices.

Item	Daily usage	Cost in Rs/day			
		A	B	Fin.	
<u>Fibrous raw material</u>					
Bagasse as fibre	1920 kg	-	113	124	196
Bagasse as fuel	1920 kg				
Cotton waste/cuttings	80 kg				
Waste paper	48	67	78	82	
		180	202	278	
<u>Chemicals</u>					
Sodium hydroxide	100 kg	193	227	239	
Chlorine	16 kg	106	124	130	
Alum	27 kg	92	108	114	
Rosin	13.5 kg	131	154	162	
Titanium dioxide	4.5 kg	37	43	45	
Daicol	11.25 kg	17	19	21	
Optical bleach	0.45 kg	4	5	5	
		579	680	716	
<u>Labour</u>					
Workers	56	364	364	906	
Supervision	7	274	274	343	
		638	638	1249	
<u>Electricity</u>					
	320 kWh	192	224	112	
<u>Misc. expenses</u>					
	IRs 80	49	49	61	
Total		1639	1794	2416	

A - accounting ratios from column A in figure A4.1

B - accounting ratios from column B in figure A4.1

The area of woven fabrics was converted to a weight at  $6 \text{ m}^2/\text{kg}^*$ . The assumptions of wastage in the textile and clothing industries are conservative. Clothing production is necessarily wasteful as non-rectangular garments are cut out of rectangular pieces of cloth. Textile factories waste less, and some of this will be as mixed natural and artificial fibres, which are difficult to separate for pulping so the estimate of wastage has been reduced to 2 %.

\* Based on the weight of four cotton shirts.

Figure A4.10 Revenue of a 400 kg/day handmade paper plant at 1977 Mauritian shadow prices.

	Type of paper sold:					
	Printing and writing			Packaging		
	A	B	Fin.	A	B	Fin.
Daily sales (400 kg/d)/Rs	2685	3152	3319	1674	1966	2070
Production cost/Rs	1638	1794	2416	1638	1794	2416
Daily net revenue/Rs	1047	1358	903	36	172	-346
Annual revenue/kRs	314	408	271	11	52	-104

A - accounting ratios as in column A of figure A4.1

B - accounting ratios as in column B of figure A4.1

Figure A4.11 Net cash flow analysis for a 400 kg/d handmade paper plant at 1977 Mauritian shadow prices.

(Cash flows in millions of rupees)	Type of paper produced:					
	Printing and writing			Packaging		
	A	B	Fin.	A	B	Fin.
Capital cost	-0.44	-0.50	-0.53	-0.44	-0.50	-0.53
Annual revenue	0.31	0.41	0.27	0.01	0.05	-0.10
NPV (1+13 years) at 5%	2.4	3.2	2.0	-0.4	-0.01	-1.5
7%	2.0	2.8	1.7	-0.4	-0.06	-1.4
11%	1.5	2.1	1.3	-0.4	-0.14	-1.2
IRR	72%	94%	50%	-14%	5%	-∞

A - accounting ratios from column A in figure A4.1

B - accounting ratios from column B in figure A4.1

Note that another approximately 1926 t of flax, hemp and jute fibres, yarn and fabric were imported in 1977 (SITC nos. 264, 265.80, 651.5, 651.92, 651.99, 653.3 and 653.4 in(3) ), the wastes from which can also be used to make paper. So, the estimate of 90 t/a of long fibre

Figure A4.12 Estimate of cotton wastes in Mauritius.

SITC	Cotton imported as:	m <sup>2</sup>	Quantity kg	Wastes %	t
263	Fibres	-	442 352		
651.40	Yarn & thread	-	1 119 585		
			1 641 937	2	33
652	Woven fabrics	8 982 131	~1 497 022	10	150
Total wastes					183
Available wastes (if 50% collected)					90

wastes available for paper production is a conservative one.

## 2. Addendum - Financial costs and benefits.

The main purpose of the previous calculations has been to check whether mini-mill technologies would be economic to the Mauritian economy from the viewpoint of the Government, by applying to the costs and benefits accounting ratios used in the "Harbour Mater Plan for Port Louis"(2). However, a project beneficial to the Mauritian economy as a whole may not necessarily be profitable for a private entrepreneur. Therefore, a check is needed on the financial costs and benefits under Mauritian conditions, to see whether the venture would be profitable on its own, or need support from the Government (in the form of subsidies or tax conditions, for example).

The financial costs and benefits have already been given in columns of the tables in this appendix. They were calculated by methods similar to those used in the social cost-benefit analyses, but with the following modifications:

- i. When actual Mauritian costs were available, they were used.
- ii. When only c.i.f. prices were available, they were divided by the ratios of import content to local price given in Scott(2), to arrive at an approximation of the local price including import duties, taxes, and distribution costs.
- iii. These ratios were also applied to the costs of equipment imported from India.

As the actual rates of import duties were not available when this calculation was made, the financial analyses are less certain than the social cost-benefit analyses. It can be seen, however, that a 15 t/d mini-mill would be as profitable financially as socially, whereas the 400 kg/d handmade paper plant would be less profitable to a private entrepreneur, and critically dependent on the quality of paper produced. Writing paper production might yield a internal rate of return of around 50%/a, whereas packaging paper production would loose money every year.

It would appear that the most useful way a government might support such a handmade paper plant, in order to increase employment, would be to fund research and development work to ensure that a good quality product could be produced from these raw materials. It might also guarantee to purchase poorer quality output for a time (until high quality paper could be produced), in return for shares equivalent in value to the subsidy element of the price paid for the paper.



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Appendix 5

Bagasse briquetting - the Southern Bagasse Co. Ltd.  
and a note of the use of second-hand equipment.

**1. History of the Southern Bagasse Co. Ltd.**

Around 1974, Jean Rey of the Mahebourg Lime Co., started looking for alternative fuels for the companies lime kilns, as firewood was becoming more scarce and costly on Mauritius. Since coal or oil would have to be imported, bagasse was the obvious fuel. This presented a technical problem, in that the lime kilns were of the vertical shaft type, in which the firewood supported the weight of the unburnt material, and provided channels through which gases could pass. When more than a small proportion of bagasse is added to such a kiln, it clogs these channels, while near the bottom of the kiln the unsupported limestone (or coral) crumbles.

Because of this, M. Rey considered briquetting the bagasse. He studied various briquetting machines, and decided upon a machine which produced high density briquettes under high pressure, since he needed them to support the weight above them in the lime kilns. Lower pressure designs, such as those used to reduce transport costs of bagasse to paper mills, or to produce animal feed pellets, were rejected.

The type chosen was that designed by the SPM Group Inc. in the USA, and sold by their Swiss associates, Pawert A.G. This produced pressures up to 240 MPa, using a 100 HP (75 kW) motor driving hydraulically a 75 mm or 90 mm piston. Such a press was rated at 1.6-2.4 t/hr capacity when using medium weight sawdust at 10-15% mois-

ture(1). The bagasse was first to be dried to 7-10% moisture using sugar factory flue gases, then blown to a screw prepress which would force the bagasse into the hydraulic press(2).

Requiring a source of bagasse, M. Rey arranged this with Savannah Sugar Estates. They set up a company, the Southern Bagasse Co. Ltd., with 51% of the shares owned by Savannah Sugar Estate, and 49% by the Mahebourg Lime Co. This company was to set up the briquetting equipment alongside Savannah sugar factory, using its bagasse to produce briquettes for sale to the Mahebourg Lime Co.(up to 4000 t/a), Bois Cheri tea factory (1000 t/a\*), and bakeries in the south of the island (100 t/a)(2). The total investment in the plant was about Rs2.5 M, all of which was put up by the shareholders, except for a three year suppliers credit of 25% of the 400 000 SF cost of the Pawert-supplied equipment(3).

The Southern Bagasse Co. arranged to buy two presses from Pawert A.G.: a new one from Switzerland, and one secondhand from Nossi-Bé in Madagascar. According to Ruckstuhl, the chairman of the SPM Group, the plant in Madagascar closed down because of difficulties in obtaining spare parts under a new government(4). Together with these two presses, the Mauritian company bought pre-presses, feeding rolls, control equipment, a fan, a rotary valve, and some conveyor parts from Pawert A.G., and arranged for the local construction of all other parts to plans supplied by Pawert A.G(1). The design was carried out by Swiss engineers unfamiliar with bagasse, as SPM's bagasse experts were busy on two other projects, and no on-site study of local conditions was carried out before preparing the quotation and

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\* The tea factory was using baled bagasse from Union St. Aubin sugar factory for fuel, and hoped to save on transport costs.

accepting the order(4).

The presses arrived in their crates in 1976, where they stayed until 1979 while a new boiler was installed in Savannah sugar factory. Finally, in 1979 the presses and bagasse drier were erected, and a Swiss engineer arrived in December 1979 to get the plant working. The sugar factory closed down a few days after he had left, so only a few tonnes of briquettes were produced. 300 t were burned in the lime kiln, and were found to be better than firewood, but some technical problems had already arisen. The bagasse was not being dried sufficiently, as the flue gas was at a lower temperature than required for the design of drier (200 °C instead of 248 °C), and the seals around the pistons were wearing badly, as a result of abrasive ash in the bagasse (from rocks loaded into the mill with the cane)(3,5).

The following season these problems continued. Also the pre-press did not function correctly, leading to uneven feeding of the briquetting press, and breaks in the briquettes. It appears that the Swiss designer had been unfamiliar with bagasse, and specified a pre-press which would work with sawdust but not with bagasse. This designer also assumed that the Mauritian bagasse was as fine as that at Emil Hugot's factory in Réunion, where SPM had supplied their first bagasse briquetting plant(4). As finer particles dry quicker than larger ones(6), the drier was underspecified for Mauritian bagasse, as prepared at Savannah sugar factory.

These design faults were of a kind that Mauritian engineers and technicians, experienced in the handling of bagasse, might have been able to overcome. Ruckstuhl suggested screening the bagasse to

remove the largest fibres and the volcanic dust(4), and there were certainly people in Mauritius experienced in the design of bagasse feeders who should have been able to replace the screw pre-press by something that worked.

Yet, nothing was done. The reaction was of inertia, rather than initiative. Jean Rey asked the technicians at Savannah sugar factory to try and get the presses working, but both the technicians and the Savannah sugar estate management had little interest in this. Rey claimed that they wanted to know if they were going to be paid by the factory or the Southern Bagasse Co.(5). Although the Savannah Sugar Estate owned 51% of the Southern Bagasse Co., the latter's success or failure was of little importance relative to sugar production#. This was far more important to the Mahebourg Lime Co., but its technicians had not, in general, had much experience of handling bagasse. So a potential conflict of interest existed, which was resolved by doing nothing.

Later, a Swiss engineer, with experience of bagasse briquetting, visited the plant. He wrote a report directly to the American company about this, and told the Mauritians that there had been fundamental mistakes in the conception of the plant(5). The American company then agreed to buy back the equipment to be installed elsewhere. As Mr. Ruckstuhl said, in a letter to the author(4):

. . . I must frankly admit that the briquetting plant which has been supplied by our Swiss associates to Jean Rey's group was a sad mistake and turned out to be a

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# Furthermore, Savannah sugar factory had the alternative of burning its surplus bagasse to produce electricity for sale to the CEB. This might not have been as profitable, but was fashionable, and within the experience of the factory management.

failure policy that we would rather lose an order if we are not given the opportunity to make a professional study prior to submitting a binding proposal and/or accept an order . . . I feel we are at the crossroads of new and exciting developments in bagasse densification, as soon as we have had the opportunity to sell a new plant into an area where local conditions are favorable.

## 2. The use of secondhand equipment in Mauritius.

In many countries, Rey's criticism of the Savannah factory technicians, for their failure to attempt modifications to the equipment to make it work, would seem unusual and unjustified. For in many places even the repair of imported equipment can be beyond the capabilities of the technicians in the firm which uses the equipment. Witness the numbers of buses and lorries abandoned in workshop yards around Moçambique, in Transportos Públicos Urbanos, ROMOS and other companies.†

However, in Mauritius, many sugar factory managers spend time outwith the crushing season, in selecting, examining, ordering and installing second-hand equipment for their factories. Some, would cast gear wheels from scrap, and design and manufacture parts for the factory. The installation is carried out by the sugar factory technicians, after renovation in the workshops (or an outside machine shop or forge, for more complicated equipment).

Once installed, the performance of the equipment (new or second-hand) is monitored, and the settings adjusted to optimum performance under the conditions in a particular factory. Where necessary, modifications are made, either on the initiative of the factory

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† Although many vehicles remained unrepaired owing to a lack of spare parts, the workshops limitations in fabricating spare parts, beyond a certain complexity, also was responsible for this situation.

staff, or in collaboration with MSIRI, where the Sugar Technology Division undertakes advisory work on specific factory problems, and studies on problems of general interest to the industry.‡

The careful selection of second-hand equipment, and the pool of technical knowledge available to the Mauritian factory managers, helped them overcome the difficulties mentioned by Cooper and Kaplinsky(8). There was no such readily available expertise on equipment outwith that regularly used in the sugar industry. M. Lagesse had to build up his own knowledge on pulp and paper-making machines by visiting working factories overseas, studying the machinery, and talking to the users (see chapter 6.1, pp.251-3). M. Rey had to rely on a study of the different manufacturers literature on the use of their plants, as the briquetter in Madagascar had not been used for some years. So he could not get the information on the productivity of this press when in use, that a second-hand dealer would have about equipment that was for sale in the dealers' area.

Under these circumstances, there is a higher risk in buying secondhand equipment, although in this case many of the problems were the result of design faults. Both the new and second-hand presses wore, although the second-hand press suffered more. What he criticised, and what is surprising only in a Mauritian context, is the lack of any attempt to modify the drier and prepress to enable the briquetter to function more efficiently.

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‡ For example, the MSIRI staff investigated the poor performance of a vacuum filter at Mon Désert Alma factory, converted to operate according to the "Rapidfloc" system, to the effect that ' . . . eventually an improvement in the de-sweetening of the cake resulted when, for the final month of the crop, the cloth lining was removed whilst the filter station was still operated according to the "Rapidfloc" system of mud conditioning.'(7)

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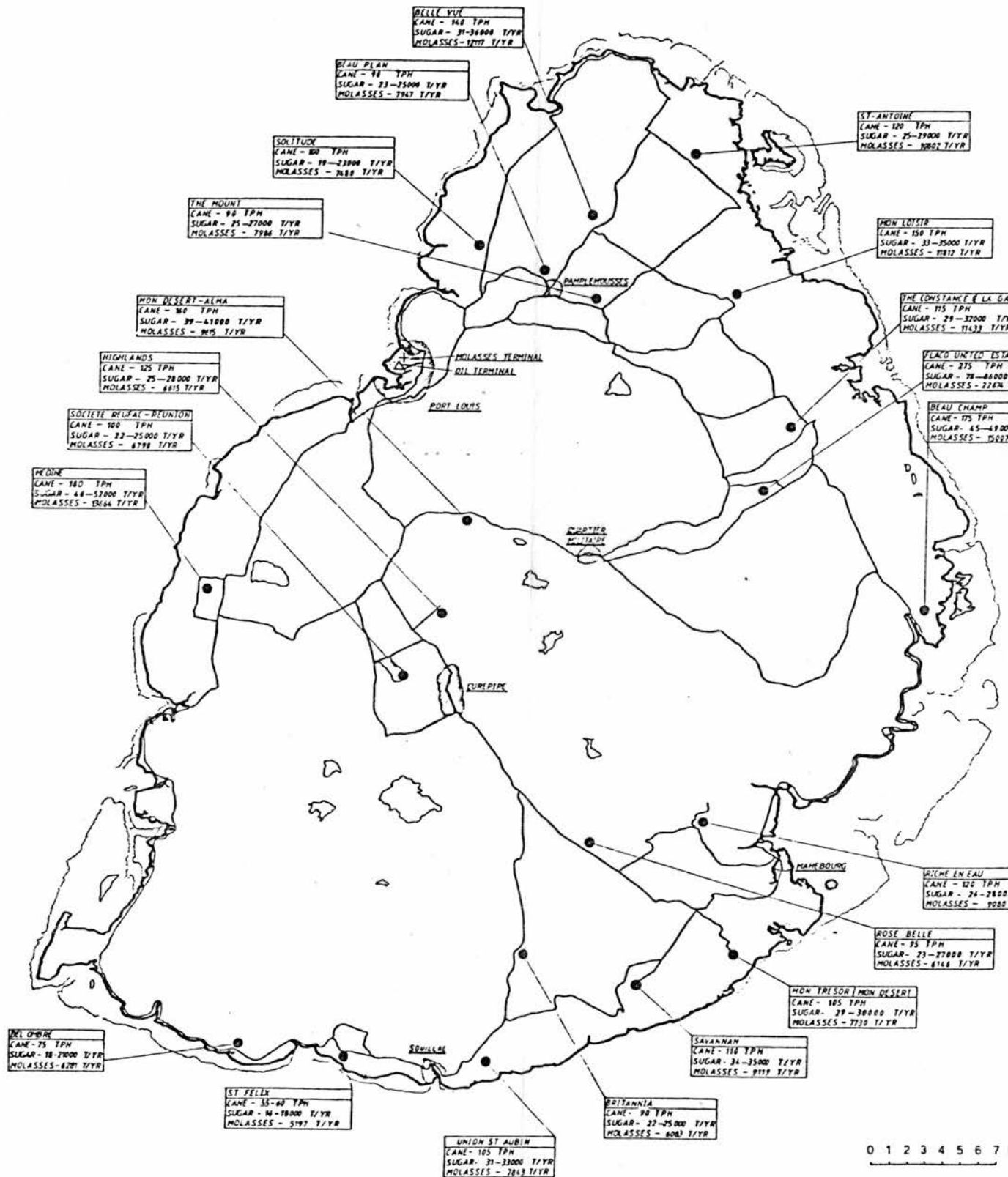


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